HOW WOOD AFFECTS FINISHES—p. 15-A

Forest Products Journal

Vol. 13, No. 2 February 1963

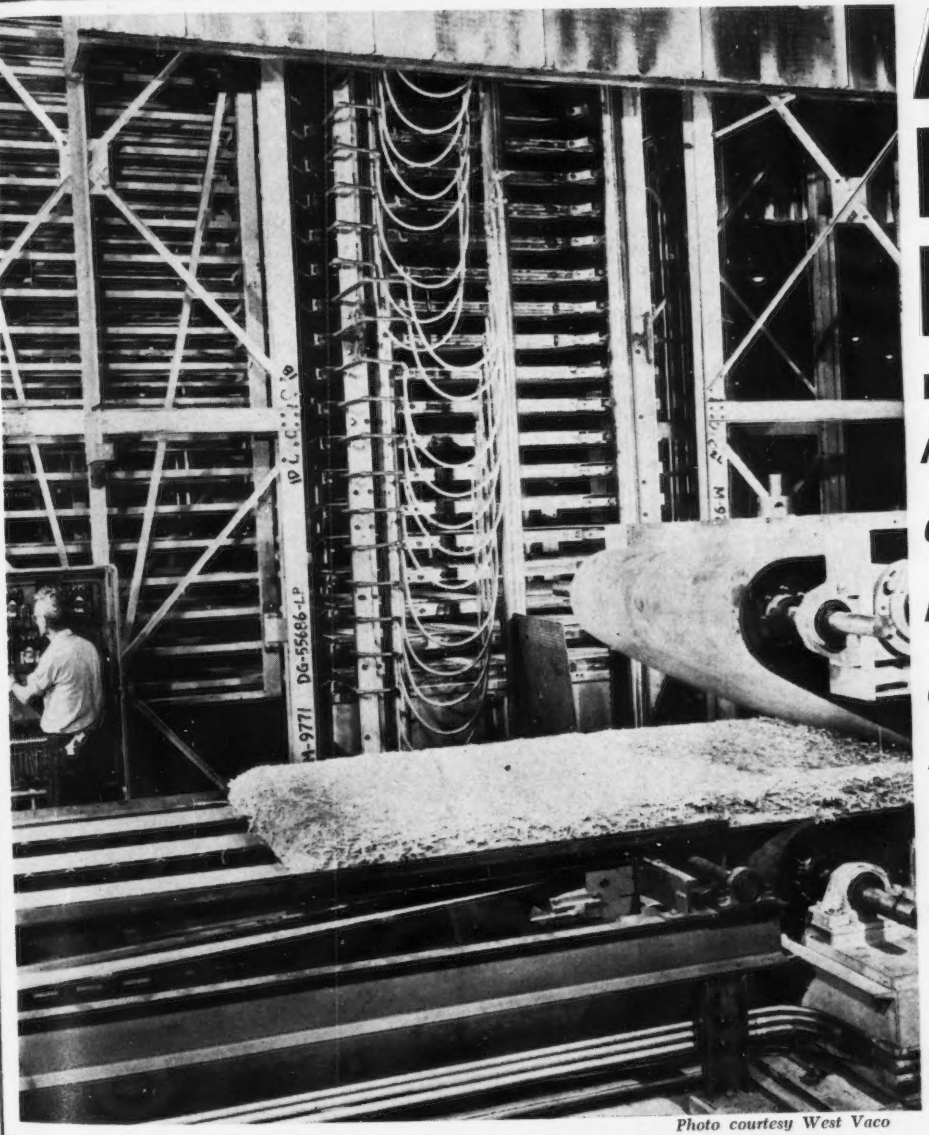


Photo courtesy West Vaco

Seen in '58—trend toward "engineered package" particle board plants.

Annual Review Issue

Wood Preservation P. 43 ▶
Merchandising P. 50 ▶
Composition Board P. 53 ▶
Lumber Manufacturing P. 57 ▶
Glues and Gluing P. 59 ▶
Logging P. 67 ▶
Wood Finishing P. 72 ▶
Wood Drying P. 81 ▶
Chemical Utilization P. 85 ▶
Quality Control P. 99 ▶

Published by the FOREST PRODUCTS RESEARCH SOCIETY BOX 2010 MADISON 5, WISCONSIN

WHERE'S THE GLUE LINE? *With new* MELURAC® *260 splicer glue* – product of Cyanamid adhesive research – splices disappear in light or dark veneer! A hint of nutshell flour gives a faint tan tint that blends with any wood. Faster curing means lower temperature splicer bars with no risk of scorching. Add only water – catalyst is incorporated. You have three to four days assembly time, very good spreading, very good washing. Or, if you don't mind adding a hardener, try nonstaining MELURAC 255. In either case, expect *invisibly* perfect results!

CYANAMID

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
32 B Rockefeller Plaza, New York 20, New York

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices in: Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Los Angeles, Minneapolis, New York, Oakland, Philadelphia, St. Louis, Seattle

FPRS

Executive Officers

President
W. Jeter Eason, Memphis, Tenn.

President-Elect
E. S. Harrar, Durham, N. C.

Vice President
R. H. Berry, Burney, Calif.

Past President
F. H. Kaufert, St. Paul, Minn.

Executive Secretary
Frank J. Rovsek, Madison, Wis.

•

Regional Board Members

Southeast
W. L. Irwin, Pickens, S. C.

South-Central
W. R. Warner, Warren, Ark.

Northeast
D. K. Saunders, Westbrook, Me.

North-Central
J. J. Allegretti, Chicago, Ill.

Northwest
T. S. Veazey, Jr., Butte, Mont.

Southwest
F. E. Dickinson, Richmond, Calif.

•

Publications Committee

Chairman
Edward G. Locke, Madison, Wis.

•

Editorial Staff

Editor
R. H. Hamre, Madison, Wis.

THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Second-class postage paid at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. IX, No. 2 February, 1959

CONTENTS

Page

1958 ANNUAL REVIEWS

Problems and Practices in Wood Preservation, 1958.....*C. S. Walters* 43
Technological advances overshadowed problems in a year of progress.

1958—Year of Decision for Wood Merchandising.....*W. B. Lloyd* 50
NLMA's $1.25 million National Wood Promotion Program is now in high gear.

1958 Status of the Composition Board Industry.....*Technical Committee, FPRS Wood Composition Board Division* 53
Statistics and developments are summarized in this first Divisional Review.

Improvements by Regions Typify Lumber Manufacturing in 1958.....*M. H. Mater* 57
The East saw most changes; trend in the South was toward centralization.

A Progress Report: Glues and Gluing, 1958.....*R. F. Blomquist* 59
Significant progress was made in both applied and fundamental studies.

Progress in Logging—1958.....*F. C. Simmons* 67
Loggers can expect to see the upswing of 1958 to continue through into 1959.

1958 Summary of Developments in Wood Finishing.....*D. G. Lubeck* 72
An extensive review of new equipment, processes, and tests, both here and abroad.

Wood Seasoning Bibliography, 1956–7.....*S. B. Preston and D. E. Nelson* 81
Selected references that deal specifically with the seasoning of lumber and veneer.

Review of Chemical Utilization.....*I. A. Pearl and A. S. Gregory* 85
Primary emphasis is on lignin and extractives, plus an extensive bibliography.

Important Activities in Quality Control in 1958.....*A. C. Barefoot* 99
Needed: a refocusing of attention on mathematical decision-making techniques.

LAMINATING

Effect of Repeated Loading and Salt-Water Immersion on Flexural Properties of Laminated White Oak.....*A. D. Freas and F. Werren* 100
After 9 million cycles at 50% of ultimate strength, beams showed no loss in bending strength or glue-bond strength.

MODIFIED WOOD

Flapreg Flakeboard . . . Resin-Impregnated, Compressed Wood Flakes.....*J. W. Talbott* 103
Flapreg, similar to compreg and impreg, is less expensive to make, should therefore have wider application.

FINISHING

Effects of Wood on Durability of Finishes.....*D. F. Laughnan* 19-A
Flat or vertical grain, density and texture, defects, amount of resin, oil, and extractives—these factors affect finish durability.

EDUCATION

A New Look at the Undergraduate Curriculum in Forest Products.....*D. B. Richards, W. B. DeVall, and J. L. Hill* 22-A
The important considerations involved in setting up an undergraduate program are presented. A stimulating discussion follows these two papers.

Educating the Wood Technologist for Research and Service.....*B. A. Jayne and R. W. Wellwood* 24-A
The goal is to produce intellectually mature technologists suited for industry, but also prepared for advanced research training.

DEPARTMENTS

FPRS News–Digest..... 11-A
Employment Opportunities..... 17-A
World-Wide Forest Products News
Helicopters in British Forests.....*R. G. Shaw* 30-A
Index to Advertisers..... 32-A

IMPORTANT FPRS DATES

April, 1959: Ohio Valley Section Meeting, New Albany, Indiana.

April 15–16, 1959: Joint Inland Empire Section—Northwest Wood Products Clinic Meeting, Spokane, Wash.

May 25–26, 1959: Joint Eastern Canadian—Northeast Spring Section Meeting, Ottawa, Ontario.

June 28–July 3, 1959: Thirteenth National Meeting, San Francisco, Calif.

Proven Products for the Forest Industries

RCI
Creative Chemistry
... Your Partner in Progress

Urea-Formaldehyde, Phenol-Formaldehyde, Polyvinyl Acetate and Resorcinol Adhesives. Protein Glues.

PARTICLE BOARD MANUFACTURER CITES UNIFORMITY OF RCI FORAMINE BINDER

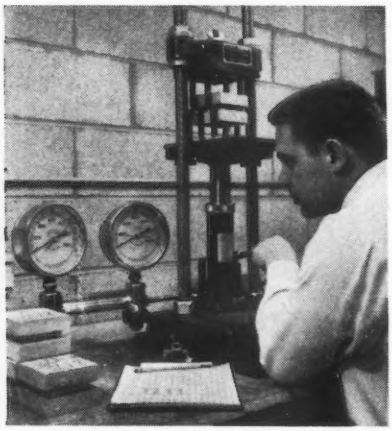
Waverly, Va.—Mr. William Newman, Quality Control Engineer of Gray Products Co., in a recent interview testified to the high quality and extreme uniformity of RCI's FORAMINE bonding resin. "The same attention and care we exercise over each step in our particle board manufacturing was brought into play in our decision to use Reichhold's FORAMINE.

Gray, one of the largest manufacturers of particle board in the country, uses Reichhold bonding resins exclusively. As a further comment on the choice of RCI as a supplier, Mr. Ed Jarrett, Plant Manager, said "Rapid delivery, coupled with high quality and dependable uniformity have made and kept us a steady Reichhold customer."

W. E. Buchanan, RCI's Technical Director — Adhesives, and Gray Plant Manager, Edward Jarrett get together to work out a production problem.

"TAILORED" SHIPMENTS

Gray's production of particle board necessitates a large and steady supply of resin binder. Reichhold, which "tailors" shipments to a customer's needs, delivers FORAMINE to Gray overnight from RCI's Charlotte, N. C. plant in 3,000 gallon insulated tank trucks. In these carriers the resin is kept at the Gray storage tank temperature of 77° F. Editor's Note: Shipments can also be made in 6,000 and 10,000 gallon railroad tank cars and in 55 gallon drums.



Gray Products Co. Quality Control Engineer, William Newman, checks the tensile strength of Grayco Flakecore particle board made with RCI FORAMINE *resin.*

TECHNICAL ASSISTANCE IMPORTANT

Mr. W. E. Buchanan, RCI's Technical Director — Adhesives, has played an important role in the Reichhold service operation developed for Gray. As Mr. Newman put it, "During the opening months of our production Mr. Buchanan was of great value to us in ironing out some fine details in our manufacturing process."

VARIETY OF RESINS AVAILABLE

Pointing to the long-run advantages of using Reichhold resins, Mr. Newman said "As we expand our line of particle board products the fact that RCI has a complete line of adhesive products available and a competent field staff to aid us in their application will become increasingly important to us."

Perhaps RCI binders and technical service can solve your particle board production problem. Write Reichhold for Booklet P.B. Reichhold Chemicals, Inc., RCI Building, White Plains, N. Y.

Kill next summer's weeds now!

SOIL STERILANTS APPLIED IN WINTER AND SPRING KEEP GROUND BARE ALL YEAR

WEED KILLERS RECOMMENDED FOR WINTER AND SPRING APPLICATION

CONCENTRATED BORASCU*—Destructive to all types of vegetation. Can be applied dry, cast by hand or with a fertilizer or seed spreader. Concentrated form saves transportation, handling and storage costs.

BARON*—Dow Chemical Company's new nonselective herbicide that remains in the soil for extended periods of time, giving control of germinating seedlings following initial treatment. Mixes easily with water.

TELVAR*—Industrial-use weed and grass killer produced by Du Pont. Wettable powder applied by sprayer, economical for large and small areas.

KARMEX*—Similar to Telvar but remains in soil longer under adverse conditions. Recommended for use in light, sandy soils and where rainfall is exceptionally heavy.

**BORASCU—Reg. trademark of United States Borax & Chemical Co., Pacific Coast Borax Co. Division. BARON—Reg. trademark of The Dow Chemical Co. TELVAR and KARMEX—Reg. trademarks of E. I. du Pont de Nemours & Co.*

CHAPMAN

CHAPMAN CHEMICAL COMPANY
Memphis 1, Tennessee

San Francisco • Portland, Ore. • Minneapolis • Charlotte, N. C.

Distributor of a complete line of weed, brush and grass killers produced by leading manufacturers.

Now is the time of year to rid yards, roadbeds, and ditches of next summer's fire-hazardous weeds and grasses. Just apply an economical soil sterilant to eliminate all vegetation for a year or more. No need for costly periodic chopping or cutting, because the weeds are killed at their roots by the poison-laden rainwater. Mail coupon for more information on these effective weed, brush, and grass killers distributed by Chapman Chemical Company.

GET THE FACTS ON CHEMICAL WEED KILLERS

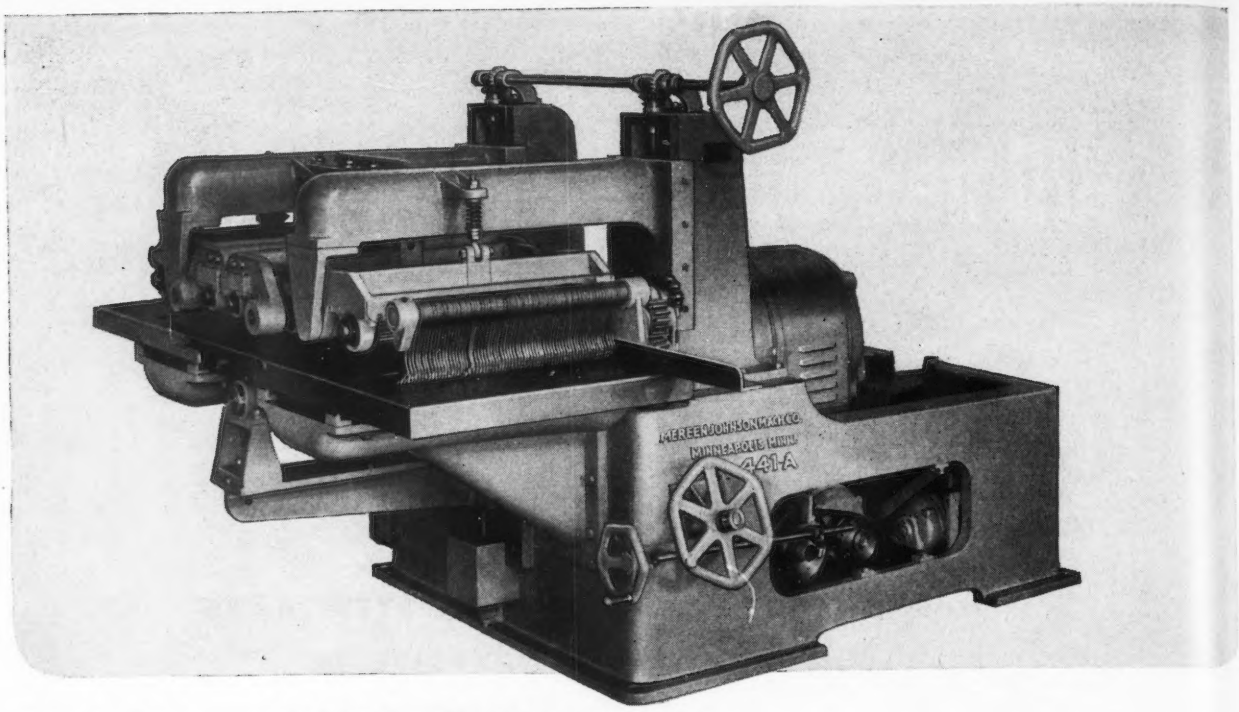
CHAPMAN CHEMICAL COMPANY
P. O. Box 138, Memphis 1, Tenn.

Please send complete information on chemical weed killers checked:

☐ Concentrated Borascu ☐ Baron
☐ Telvar ☐ Karmex

*Name*_____

*Address*_____



MEREEN-JOHNSON NO. 441A

extra heavy duty GANG RIP SAW

MEREEN-JOHNSON has manufactured gang rip saws for 40 years. Power, speed and accuracy have always characterized M-J machines. This new No. 441A has all the features of previous models, with some important new ones added.

- Now *eight power-driven feed rolls*—two pair infeed and two outfeed. This is a double safeguard where utmost accuracy of production is required.
- 7200 RPM arbor speed puts extra power where it's needed.
- Vertical arbor adjustment simplifies bed plate removal.

If your production includes sheet materials, hardwood flooring, furniture core stock or wirebound boxes—it will pay you to investigate this big, rugged M-J No. 441A Rip Saw.

ONE-PIECE ARBOR BEAM

Exclusive with M-J is this beam mounting of motor, arbor and bearings in a single rigid unit.

MEREEN-JOHNSON MACHINE CO.
4401 LYNDALE AVE. NO. • MINNEAPOLIS 12, MINNESOTA

CUT-OFF SAWS	DOUBLE CUT-OFF SAWS	MULTIPLE CUT-OFF SAWS	GANG RIP SAWS
TENONERS	VENEER & PLYWOOD SIZERS & JOINTERS		RESAWS

Send for the No. 441A Bulletin on your company letterhead.

the right glue...

used right—

vital to Wabash wood particle board

National Casein's urea resin and casein glues play a dual role in the utilization of wood residue to meet the Nation's expanding wood product needs.

First: National Casein's #750 urea resin is a preferred adhesive for bonding the wood particles into strong, durable core stock. It is water, work and wear resistant.

Second: National Casein's Glues are preferred adhesives for laminating veneers, or other materials used in the finished product to particle board.

National Casein's #750 Urea Resin contributes strength and longevity to a preferred core stock for table and counter tops, desks, cabinets, cupboard doors, veneering and plastic laminating.

Wabash Wood Particle Board is made of dry, clean and uniform particles of light colored soft woods . . . coated with a blend of National Casein's water-resistant synthetic resins and bonded under controlled heat and pressure . . . then conditioned to moisture content requirements.

Result is an economical, water-resistant, dimensionally stable, density uniform, and highly workable wood product.

The National Casein Glue Man who calls on you has interesting and helpful information and data on the subject of particle board manufacture and on its subsequent processing for consumer use.

Your NC Glue Man

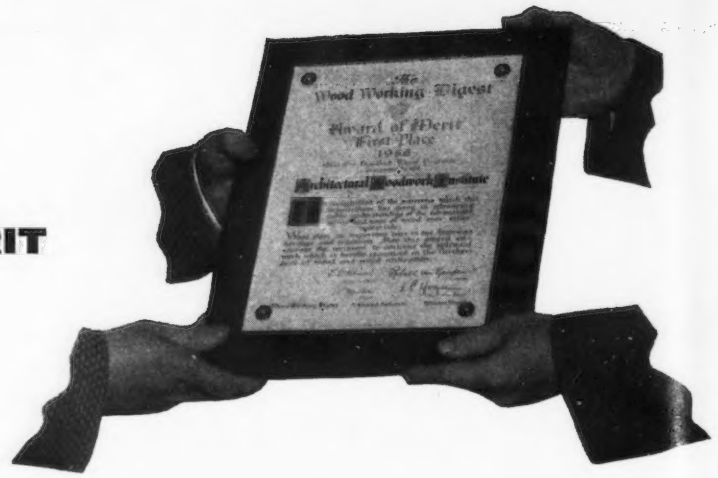
National Casein

Announcing the...

Sixth Annual

AWARD OF MERIT

Citations



Awarded by

HITCHCOCK'S

WOOD WORKING

Here is your opportunity to nominate some organization for an award of merit based on significant contributions to the promotion or utilization of *wood* during 1958.

You may use **this form to nominate your own organization or some other company, association or institution in any one of the four classifications shown. Nominations must be received by March 15, 1959. Awards will be made at the National Meeting of the Forest Products Research Society in June in San Francisco.**

NOMINATION FORM

Hitchcock's WOOD WORKING
Wheaton, Illinois

I hereby nominate for a 1959 Award of Merit

Organization_____

Address_____

City_____ State_____

. . . suggesting this organization for an award in the category checked:

☐ Producers or manufacturers of wood or wood products
____with less than 100 employees
____with 100 or more employees

☐ Associations

☐ Public institutions and universities

☐ Suppliers of equipment or supplies used by wood products manufacturers.

NOMINATIONS MUST BE RECEIVED BY MARCH 15, 1959

Your name_____

Organization_____

Address_____

City_____ State_____

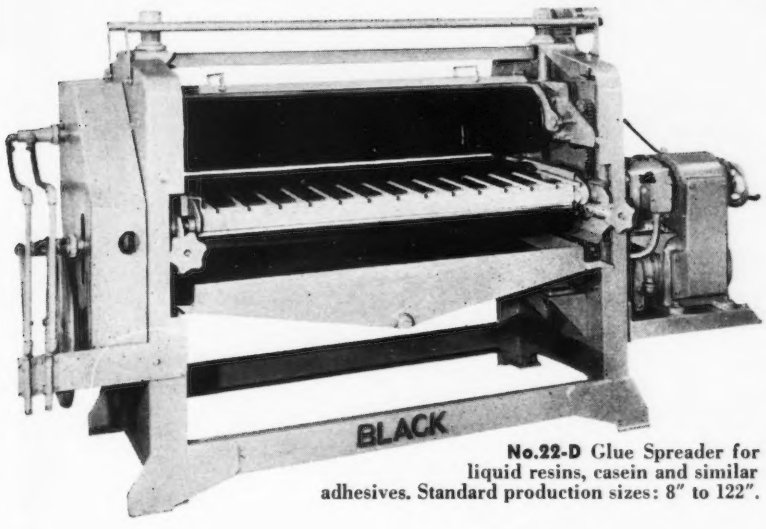
Brilliant New Successes in Gluing and Laminating

A West Coast manufacturer speeds production of hollow core flush doors with the No. 22-D, 50".

For glue testing and development work, a leading glue manufacturer depends on the No. 22-D Spreader.

Versatile No. 22-D Spreader helps produce laminated beams and roof trusses at a California mill.

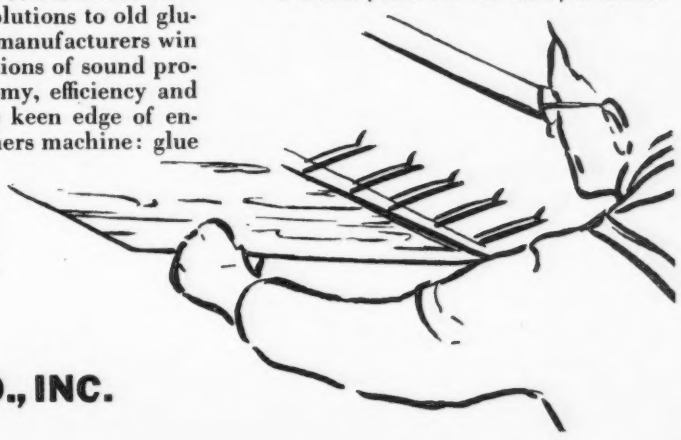
Fast, economical production of plywood in a Finnish plant. The No. 22-D, of course.



No.22-D Glue Spreader for liquid resins, casein and similar adhesives. Standard production sizes: 8" to 122".

On production lines, in glue rooms and laboratories . . . Black Brothers Gluing and Laminating Equipment provides new solutions to old gluing and laminating problems. Helps cost-conscious manufacturers win new competitive markets, too, through new applications of sound production techniques. Preferred for its proven economy, efficiency and speed, the versatile No. 22-D Spreader reflects the keen edge of engineering skill incorporated into every Black Brothers machine: glue spreader, mixer, press or clamp.

Shouldn't you consider a Black Brothers installation? Write for our Supplement to Bulletin No. 11-A which gives construction details and specifications on the No. 22-D Glue Spreader.



THE BLACK BROTHERS CO., INC.
MENDOTA 8, ILLINOIS

PRICE LIST

INDIVIDUAL COPIES OF FPRS PUBLICATIONS

FOREST PRODUCTS RESEARCH SOCIETY — **417 N. WALNUT ST., MADISON, WIS.**

ANNUAL PROCEEDINGS

(Cloth Binding)

- ☐ Vol. 1, 1947 344 pages ---------- $2.00
- ☐ Vol. 2, 1948 500 pages ---------- $2.00
- ☐ Vol. 3, 1949 607 pages ---------- $2.00
- ☐ Vol. 4, 1950 506 pages ---------- $2.00
- ☐ Vol. 5, 1951 400 pages ---------- $2.00

FOREST PRODUCTS JOURNAL

(Paper Binding)

Volume I, 1951

- ☐ No. 1, September ---------- $1.00

Volume II, 1952

- ☐ No. 1, April ---------- Out of print
- ☐ No. 2, June ---------- Out of print
- ☐ No. 3, September ---------- Out of print
- ☐ No. 4, November ---------- $1.00
- ☐ No. 5, December, Annual Proceedings ------ $2.00

Volume III, 1953

- ☐ No. 1, February ---------- $1.00
- ☐ No. 2, June ---------- $1.00
- ☐ No. 3, September ---------- $1.00
- ☐ No. 4, November ---------- $1.00
- ☐ No. 5, December, Annual Proceedings ------ $2.00

Volume IV, 1954

- ☐ No. 1, February ---------- $1.00
- ☐ No. 2, April ---------- $1.00
- ☐ No. 3, June ---------- $1.00
- ☐ No. 4, August ---------- $1.00
- ☐ No. 5, October, Annual Proceedings -------- $2.00
- ☐ No. 6, December ---------- $1.00

Volume V, 1955

- ☐ No. 1, February ------- $1.00
- ☐ No. 2, April ---------- $1.00
- ☐ No. 3, June ---------- $1.00
- ☐ No. 4, August -------- $1.00
- ☐ No. 5, October, Yearbook $2.00
- ☐ No. 6, December ------ $1.00

Volume VI, 1956

- ☐ No. 1, January -------- $1.00
- ☐ No. 2, February ------- $1.00
- ☐ No. 3, March --------- $1.00
- ☐ No. 4, April ---------- $1.00
- ☐ No. 5, May ---------- $1.00
- ☐ No. 6, June ---------- $1.00
- ☐ No. 7, July ---------- $1.00
- ☐ No. 8, August ---------- $1.00
- ☐ No. 9, September ---------- $1.00
- ☐ No. 10, October, Yearbook ---------- $2.00
- ☐ No. 11, November ---------- $1.00
- ☐ No. 12, December ---------- $1.00

Volume VII, 1957

- ☐ No. 1, January ---------- $1.00
- ☐ No. 2, February ---------- $1.00
- ☐ No. 3, March ---------- $1.00
- ☐ No. 4, April ---------- $1.00
- ☐ No. 5, May ---------- $1.00
- ☐ No. 6, June ---------- $1.00
- ☐ No. 7, July ---------- $1.00
- ☐ No. 8, August ---------- $1.00
- ☐ No. 9, September ---------- $1.00
- ☐ No. 10, October, Yearbook ---------- Out of print
- ☐ No. 11, November ---------- $1.00
- ☐ No. 12, December ---------- $1.00

Volume VIII, 1958

- ☐ No. 1, January ---------- $1.00
- ☐ No. 2, February ---------- $1.00
- ☐ No. 3, March ---------- $1.00
- ☐ No. 4, April ---------- $1.00
- ☐ No. 5, May ---------- $1.00
- ☐ No. 6, June ---------- $1.00
- ☐ No. 7, July ---------- $1.00
- ☐ No. 8, August ---------- $1.00
- ☐ No. 9, September ---------- $1.00
- ☐ No. 10, October, Yearbook ---------- $2.00
- ☐ No. 11, November ---------- $1.00
- ☐ No. 12, December ---------- $1.00

Delivery charges will be paid if remittance in full is received with order.

ORDER FORM

Forest Products Research Society
417 North Walnut Street
Madison 5, Wisconsin

Date ----------

Please send me copies of the publications checked above. Remittance of $---------- is enclosed in payment.

Name ----------

Company ----------

Address ----------

City ---------- Zone ------ State ----------

(Please type or print)

Note: All prices quoted include prepaid postage.

FOR A LIMITED TIME ONLY, TO REDUCE OUR INVENTORY

Important Savings

IN PRICES OF BACK ISSUES OF FPRS PUBLICATIONS

1. ANY SINGLE COPY ANNUAL PROCEEDINGS, 1947–1954 . . .

Each volume ranges from 286 to 607 pages and sold originally from $5.00 to $10.00. Each contains all of the published National Meeting papers for that year, covering a general cross-section of modern wood technology. (Volumes 1947 through 1951 are cloth-bound. Volumes 1952–54 are paper-bound and were originally issued as Journals in that year.) Annual Index contained in December issue.

$2.00
POST PAID ANYWHERE

2. 12 ISSUES FOREST PRODUCTS JOURNAL, 1956 OR 1958 . . .

Originally to obtain these Journals you would have had to pay $15.00. Today you can complete your library for just 1/3 of the original price. The 12 issues for each year contain from 964 to 1046 pages of information covering modern wood technology. Annual Index appears in December issue.

$5.00
POST PAID ANYWHERE

INCOMPLETE SET 1957 (11 ISSUES) . . .

In 1957 the October "Yearbook" issue is out of print. The remaining 11 issues, or a total of some 900 pages, are available at a considerable savings over original cost. Annual Index appears in December issue.

$4.00
POST PAID ANYWHERE

3. ALL 6 ISSUES JOURNAL 1954 OR 1955 (5 ISSUES 1953) . . .

In these years the Society published fewer issues of the Journal but more pages per issue (736 to 852). Original cost $15.00 . . . now available at but a fraction of this price. Annual Index appears in December issue.

$4.00
POST PAID ANYWHERE

To: Forest Products Research Society
417 North Walnut Street
Madison 5, Wisconsin

Yes ! Send me the following Proceedings or Journal sets. I am enclosing check or money order to cover same.

- ☐ 1947 Proceedings -- $2.00
- ☐ 1948 Proceedings -- $2.00
- ☐ 1949 Proceedings -- $2.00
- ☐ 1950 Proceedings -- $2.00
- ☐ 1951 Proceedings -- $2.00
- ☐ 1952 Proceedings -- $2.00
- ☐ 1953 Proceedings -- $2.00
- ☐ 1954 Proceedings -- $2.00
- ☐ 1953 set of Journals -- $4.00
- ☐ 1954 set of Journals -- $4.00
- ☐ 1955 set of Journals -- $4.00
- ☐ 1956 set of Journals -- $5.00
- ☐ 1957 set of Journals -- $4.00
- ☐ 1958 set of Journals -- $5.00

Total Enclosed $_____

Name _____

Firm _____

Street _____

City _____ State _____

Research is responsible for these four men on the Ivory Pine mill floor producing 60,000 bd. ft. of lumber per eight-hour shift—one of the many examples of "profits through research".

Research Scores Again!

At the FOREST PRODUCTS RESEARCH SOCIETY 13th NATIONAL MEETING

In Fabulous SAN FRANCISCO

JUNE 28-JULY 3

Make Plans Now to Attend
F.P.R.S.' 13th National Meeting
In Fabulous San Francisco, June 28–July 3, 1959

FPRS News-Digest

Advance National Meeting Technical Program Announced

THE ECONOMIC IMPLICATIONS of research results will be emphasized at the technical sessions of FPRS' 13th National Meeting, June 28–July 3, in San Francisco, according to E. S. Harrar, Dean, School of Forestry, Duke U., and technical program chairman for the meeting.

Over-all theme for the meeting is "Research for Profit". A record twenty technical sessions will be presented by the 14 FPRS Divisions during the 5-day meeting. They will be built around the presentation of papers, and floor and panel discussions.

THE ST. FRANCIS, San Francisco's largest hotel, and FPRS' headquarters, overlooking Union Square in the center of the city.

Wood Composition Board, June 29

Three panel discussions on particle board will be featured at the first Wood Composition Board session scheduled Monday morning, according to program chairman A. L. Mottet, International Paper Co. To be discussed are manufacturing problems, particle board research, and board uses and markets.

The second session will be held Thursday afternoon, July 2. Papers will deal with "Composition Board Marketing, Research and Development"; "Bending Strength of Wood Particle Board under Long-Term Loading"; "A Great Challenge to the Particle Board Industry—Development of Standards"; "The Effect of Formation Variables on the Properties of Wood Particle Moldings". "Durable Adhesives for Particle Board"; and "Particle Geometry as Related to Dimensional Stability."

Veneers and Plywood, June 29

Five papers will be presented at the Veneers & Plywood session, Monday morning, June 29, program chairman J. F. Lutz, U. S. Forest Products Laboratory reports. The program will begin with a paper on "The Potential of Western Hardwoods for Veneer and Plywood", by P. H. Koehler, Timberline, Inc. Lawrence Leney, U. of Missouri, will present a paper entitled "Motion Picture Studies of Action at the Edge of the Veneer Knife". "Lathe Check Formation in Douglas-fir Veneer" will be given by E. Hobart Collins, Weyerhaeuser Timber Co. "A New Performance Test for Interior Plywood and Its Application to Panels Containing White Pocket" will be discussed by Robert Ripley, Douglas-fir Plywood Assoc.; and George Atherton and J. B. Grantham, Oregon Forest Products Research Center, will present a paper on "Veneer Production from Heated and Unheated Douglas-fir Logs".

Wood Machining, June 29

Among the topics to be discussed at the Wood Machining session, Monday morning, are: "Stresses in Circular Saws"; "Performance Characteristics of Combination Circular Sawblades"; "Precision Production Sanding of Plywood and Particle Board" and "Cross-Cutting with Chain Saw Teeth." Program chairman is Robert J. Hoyle, Jr., Potlatch Forests Inc.

Glues and Gluing, June 29

Two sessions are planned by the Glues and Gluing Division, according to B. S. Bryant, program chairman of both sessions. The first is scheduled for Monday morning, at which C. C. Booth, the Borden Co., will present a paper on "Elastomeric Adhesives—Their Application in the Forest Products Industry". "Finger Jointing at High Moisture Contents" will be discussed by R. A. Currier, Oregon Forest Products Research Center. Other topics at the session will include "Elastomeric Adhesives—Their Technology", and "A New Approach to Lumber Laminating".

"Whose Responsibility is Glue-Bond Quality in the Plywood Industry?" will be the theme of a panel discussion at the second Glues & Gluing session, Wednesday morning, July 1. Robert Ripley, Douglas-Fir Plywood Assoc., will represent the industry association viewpoint; John Hine, West Coast Adhesive Manufacturers, the adhesive manufacturers' viewpoint; K. K. Graves, Georgia–Pacific Corp., the plywood manufacturers' viewpoint; and L. A. Patronsky, Timber Engineering Co., the industry-supported testing laboratory viewpoint.

Chemical Utilization, June 29

The Chemical Utilization Division is also planning two sessions. One will be held Monday afternoon, and the second, Thursday morning, July 2. Program chairman is E. G. Locke, USFPL.

National Meet Program Cont'd.

Wood Preservation, June 29

The Wood Preservation session will be held Monday afternoon, A. H. Bishop, N. Y. college of forestry, program chairman reported recently. Papers include, "Fire-Retardants for Wood Treated with Oil-Type Preservatives" and "Flame-Spread Measurements on Wood-Base Materials Using Radiant Panel Test Method."

Logging, June 30

Six papers will be presented at the Logging session, Tuesday morning. W. A. Davies, Oregon State College, will speak on "Small Log Harvesting in the Douglas-Fir Region". "Bacterial Infection of Log Ponds" will be discussed by Eric Ellwood and Barton Ecklund, U. of California Forest Products Laboratory and Emanual Fritz, consultant and program chairman, will present a paper on "Timber Sale & Logging Contract Writing". Other topics to be covered are "Veneer Log Purchase and Handling", "Selective Cutting Benefits", and "Prospects of Higher Load-Carrying Capacity of Helicopters for Possible Use in Logging".

Wood Drying, June 30

Program chairman Eric Ellwood, U. of California, has announced five papers for the Wood Drying session, Tuesday morning. "The Shrinkage and Elastic Properties of Ray Tissue as Factors Contributing to the Shrinkage of California Black Oak" will be the title of a paper by A. P. Schniewind, U. of California. D. M. Post, U. of Fla., will discuss "Air Circulation in Forced-Air Drying of Lumber," and W. B. Fearing and A. B. Anderson, U. of California, will speak on "The Solvent Seasoning of Tanoak". "Calculation of Drying Stresses in Wood" will be presented by R. L. Youngs, USFPL, and "The Control of Brown Stain in Sugar Pine" will be covered by R. E. Stutz, Western Pine Assoc.

Wood Finishing, June 30

Two sessions will be held by the Wood Finishing Division. The first, on Tuesday morning, will have as its theme, "Recent Developments in Processing Equipment and Techniques". Tuesday afternoon another session will be held on "Recent Developments in Finishing Materials". Program chairman for both sessions is Don Laughnan, USFPL.

Lumber Manufacturing, June 30

The Place of the Sawmill in an Integrated Forest Operation is the theme of the Lumber Manufacturing session to be held Tuesday afternoon. L. W. Hooker, Michigan College of Mining & Technology, will speak on "What is an Integrated Forest Operation?" D. E. Lane, B. C. Forest Products Ltd., will present a paper on "The Place of the Sawmill in a Predominately Douglas-Fir Integrated Forest Operation", and "Log Segregation in an Integrated Forest Operation" will be discussed by Herbert I. Winer, Yale University. The last paper will be on "Products Output from a Predominately Pine Integrated Forest Products Plant".

Packaging, June 30

The Packaging Division plans to hold a session during this year's meeting. It is scheduled for Tuesday afternoon, according to A. R. Tegge, Quartermaster Food & Container Institute, program chairman. Papers to date include "What's New in Pallet Assembly", and "Pallet Bins for Harvesting Apples in the Pacific Northwest." Tentative papers include "Spiral Wrapping Machine for Panels" and "Wood Cellulose Cushioning for Packaging."

Lumber and Wood Drying, July 1

A joint session of the Lumber Manufacturing and Wood Drying Divisions will be held Wednesday morning. "Using Research Results Effectively in Lumber Manufacture" will be discussed by Clifford Anderson, Winton Lumber Co. A panel discussion for the remainder of the session will deal with "The Effect of Weighting Lumber Piles", "Lumber Segregation for Best Results in Drying", and "Recent Research Results and Their Application in the Lumber Industry".

Industry-Education, July 1

"Industry's Education Responsibilities" is the theme of the Industry–Education session to be held Wednesday morning, according to N. V. Poletika, Union Lumber Co., program chairman. To be discussed are: "Education for Manufacturers and Users of Wood"; "Education Sells Wood Structures — A Company's Experience"; "An Architect's Analysis of the Forest Products Industry's Education Responsibilities"; and "The Community's Stake in Wood's Future".

Merchandising, July 2

"Wood Promotion — Whose Responsibility?" is the theme of the Thursday morning Merchandising session. A lumber retailer, a lumber wholesaler, and a lumber manufacturer will discuss the theme in a panel discussion.

General Session, July 2

One general session will be held Thursday morning. E. S. Harrar is program chairman for the session. Papers include: "Process of Converting Sawdust into Fertilizer Carrier and/or Soil Conditioner"; Merchandising Aspects of Non-Combustible Wood" by Ralph Bescher, Koppers Co.; and "An Integrated Sawmill—Lumber Operation".

Quality Control, July 2

A session on quality control is scheduled for Thursday afternoon, according to program chairman A. C. Barefoot, N. C. State College. "The Usefullness of Surface Texture Measurements for Quality Control" will be presented by D. A. Stumbo and J. E. Marian, U. of California Forest Products Laboratory. Other topics will be "Linear Programming in Sawmill Operations", and "Methods and Machines for Quality Control of Forest Products."

Woodworking "Awards" to be Made at National Meeting

The annual Hitchcock Publishing Co. "Award of Merit" citations will again be given during the National Meeting of FPRS, at San Francisco. This year, the awards will be announced at the Merchandising session, July 2.

Any organizaiton, association, or public institution that has been of outstanding service, or has made an outstanding contribution to the woodworking industry in promoting wood and the utilization of wood during 1958, may be nominated.

The purpose of the annual citations is to recognize and reward those who have promoted and encouraged the desirability of wood over other materials, and the use of wood products; to call attention, within the industry to the need for public information and education; to publicize the ways and means that are being used to prove the advantages of wood; and to combine the promotional efforts on the part of organizations within the woodworking industry.

Awards will be given to one producer or manufacturer with less than 100 employes, to one with more than 100 employes, to an association, to a public institution or university, and to a supplier of the wood products industries. Nominations should be sent to Hitchcock Publishing Co., Wheaton, Ill.

Recipients of the Award in past years have included such organizations as Monsanto Chemical Co., Weyerhaeuser Timber Co., and others.

NLMA–FPRS Career Opportunities Program Goes Into High Gear

Distribution of "Opportunities Unlimited", the NLMA–FPRS booklet designed to attract students to the forest products industries, has been launched by the National Lumber Manufacturers Assoc. The program is being directed by Dr. John Zerbe, NLMA staff member.

To date, 50 to 100 copies of the booklet have been mailed to every forestry school in the nation. Copies have also been mailed to each of the FPRS' 14 Sections. Nine FPRS Sections have appointed Industry-Education committees to help in the distribution. They are: Southeastern, Great Lakes, Mid-South, Mid-West, Northeast, Inland Empire, Rocky Mountain, Pacific Northwest, and Upper Mississippi Valley. The five remaining Sections are expected to appoint such committees in the near future.

RECRUITMENT LITERATURE is becoming more plentiful thru NLMA.

FPRS Cooperation Invited

The distribution program will use various means:

1) FPRS Section Chairmen and Education Committees will be urged to seek local industry sponsorship of "career days", mill tours, and so forth, where copies of the booklet can be distributed. Booklets may be purchased by the company sponsors at 10¢ each and imprinted if desired.

2) The National Office will promote copies in response to numerous write-in-requests.

3) Single copies of the booklet, along with directions for use, will be distributed to vocational guidance counselors. Where possible, forestry schools will make these mailings.

4) The program will be publicized through talks at various FPRS Section meetings.

Many queries for additional copies of the booklet have been received from forestry schools, Dr. Zerbe reports. One of the most varied promotional programs, he said, is being carried out by Oregon State College. The College has "High School Career Days", visitation programs in which staff participates. An annual event on the campus is the "Junior Scientists and Engineers Institute". A once-a-year mailing is made to all high school counselors in Oregon, and the School of Forestry Alumni Assoc. recently initiated a direct-contact program with some 200 outstanding high school students.

SECTIONS in the NEWS

N. W. Wood Products Clinic—FPRS Inland Empire Section Sponsor Joint Meeting April 14–15

The Inland Empire Section will again hold a joint meeting with the 14th Annual Northwest Wood Products Clinic, according to W. H. Knight, secretary of the Clinic. Dates are April 14–15. Headquarters will be the Davenport Hotel, Spokane.

The program will be divided into four sessions. "A Wood Industries Clinic" is scheduled Tuesday morning, April 14, and will be in the form of eight or ten roundtable discussions with a moderator at each table. Each table will concern itself with a distinct wood product industry problem.

A special commemoration of the 50th anniversary of the School of Forestry at the U. of Idaho will be made at the luncheon Tuesday noon. Principal speaker will be Leo Bodine, Diamond Match Co.

Session two, Tuesday afternoon, will be on "Residue Utilization", and will cover such topics as Flapreg, a new product developed by the Washington State Institute of Technology, and bark possibilities.

FPRS' Inland Empire Section will present the third session on Wednesday morning, April 15. Subjects will include, "Flakeboard—A Means of Mill Waste Utilization", and "Low-Grade 1-inch Boards".

"Glues and Gluing" is the topic of the fourth session, planned Wednesday afternoon. Two papers, entitled "Edge Gluing" and "Beam Laminating" will be followed by a panel on glue processing. Several members of the Northwest chemical companies will participate in the latter.

"FPRS Salutes"

Men Contributing Time and Effort for Furtherance of the Society and Wood Industry

E. S. Harrar—FPRS President-Elect and Program Chairman for the 13th National Meeting, is responsible for the development of the technical program to be presented at San Francisco. Dr. Harrar has served the FPRS long and well. In addition to leading the organization of the Carolina's–Chesapeake Section, he was Regional Board Member (1954–56) and National Vice President in 1957.

A native of Pittsburgh, Pa., Dr. Harrar received his BS in '27, MS in '28, and PhD in '36, from New York State College of Forestry for studies in wood technology. Eight years of teaching at the University of Washington were followed by a professorship in 1936 at the School of Forestry, Duke University, where he is now dean. During World War II he served as chief administrative engineer for Curtiss-Wright, Airplane Division.

Besides co-authorizing textbooks on dendrology and forest product, Dr. Harrar has written about 60 other books and technical papers.

William G. Van Beckum—chairman of the Social and Hospitality Committee for the 13th National Meeting, is in charge of organizing such traditional activities as the FPRS annual party. Mr. Van Beckum has been Director of Research and Development for The Pacific Lumber Co., San Francisco, for the past six years.

A native of Wisconsin, he received his BA from St. Norbert, De Pere, Wis., and an MA from the University of Wisconsin. He was with Weyerhaeuser Timber Co. for 10 years in research and sales.

Victor S. Roth—takes on a variety of problems as chairman of the committee arranging for exhibits, signs, visual aids, and a public address system for the National Meeting in San Francisco. Now owner of the Triangle Lumber Co., Oakland, Calif., Mr. Roth has been employed as a grader, superintendent, and manager of three other California lumber or wooden-box manufacturing firms.

Although he is a long-time resident of California, Mr. Roth was born in Vancouver, British Columbia. He studied business administration at Harms School of Business. Active in community affairs, he also participates in the Sierra-Cascade and the Redwood Region Logging Conferences.

Two Days of National Meeting Plant Tours Scheduled July 2, 3

An important feature of the Thirteenth National Meeting in San Francisco, will be visits to a variety of wood industry plants and to a research laboratory, according to Tom Shelton of the Diamond Gardner Corporation, Chairman of the Plant Trip Arrangement Committee.

On Thursday, July 2, groups will visit Fibreboard Products Corporation, Antioch; Michigan–California Lumber Company, Camino; and the University of California Forest Products Laboratory, Richmond. All-day trips on Friday, July 3, include Union Lumber Company, Fort Bragg; Masonite Corporation, Ukiah; and the Diamond Gardner Corporation, Red Bluff.

Advance sign-up during the meeting will be required for all who wish to participate in one or more of the field trips. A charge will be assessed to cover the cost of transportation—by chartered bus on all trips except the one to Diamond Gardner Corporation at Red Bluff, which will be by chartered aircraft.

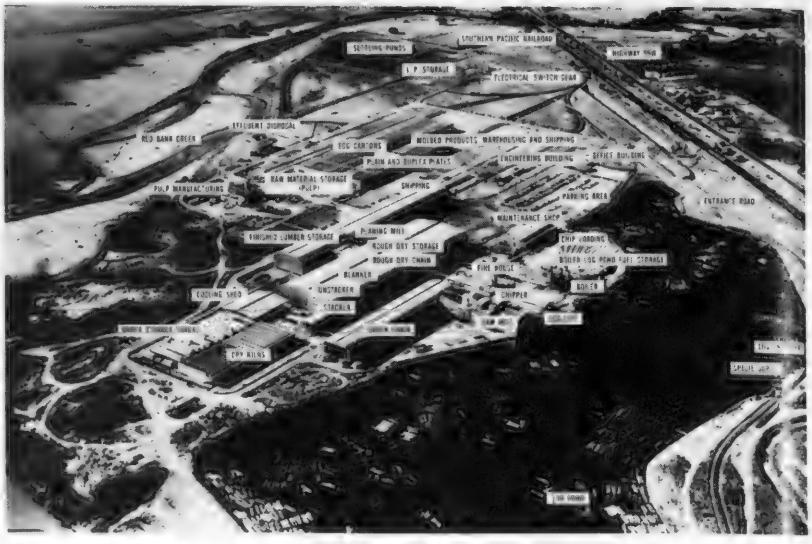
The committee has chosen operations of quite divergent character so that a variety of interests can be served and many unique features can be examined.

Pulp and Containerboard Mill

The Fibreboard Products Corporation has its main office in San Francisco with production facilities located at Antioch about 40 miles from San Francisco. The principal product of this company is containerboard, and both sulfate and semichemical pulp are produced. Most of the raw material arrives at the mill in the form of chips, which have been produced at various sawmills in California from mill residuals. Raw materials consist of Douglas fir, ponderosa and sugar pine, white fir, and some eucalyptus. Located on the site of the Antioch mill is a complete research laboratory.

Pine Lumber Mill

The Michigan–California Lumber Company, Camino, is located in the heart of the Sierra pine region. The company and its predecessors have been in operation since about 1888. The company owns 85 thousand acres of timberlands of which approximately half is still covered with virgin timber. The company has always been interested in long-term aspects of forest management, and endeavors to operate its lands on a permanent basis. The mill at Camino was built in 1950. Operating on a one shift basis the year around, this mill produces approximately 45 million feet of lumber yearly. This is composed of approximately 50 per cent pine and 50 per cent associated species (mainly white fir). The Michigan–California sawmill is an excellent example of an up-to-date mill operating in the pine region. All logs going into the mill are debarked, and mill residuals are shipped and sold for pulping purposes. Practically all production is kiln dried, and much of it is processed through the company's modern planing mill.



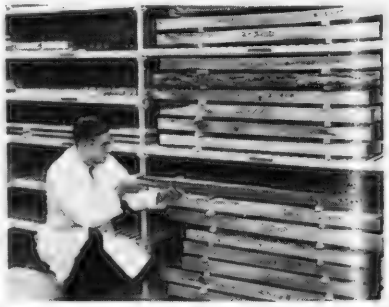
AERIAL VIEW of new multi-million dollar integrated forest products plant of the Diamond Gardner Corporation, Red Bluff.

California Forest Products Lab

AERIAL VIEW of the California Forest Products Laboratory at Richmond, Cal.

The University of California Forest Products Laboratory is located in Richmond, just across the bay from San Francisco, on the University's 104-acre Richmond research station. A staff of two dozen scientists directs a research program covering both chemical and physical aspects of wood utilization. The main objective is to achieve better and more complete utilization of California's timber crop. Visitors will have an opportunity to see a number of projects under way in the field of wood extractives, solvent seasoning, kiln drying, gluing, and many others. An interesting feature is the Laboratory's buildings, which are constructed principally of redwood and provide about 25 thousand feet of floor space for research activities.

DR. EUGENE ZAVARIN using the ultraviolet spectrophotometer to determine the identity of an unknown organic compound extracted from incense cedar.



DONALD STUMBO selecting specimen material for strength tests of Pacific madrone.

ESLIE SMITH conducting an extraction of sugar pine sawdust.

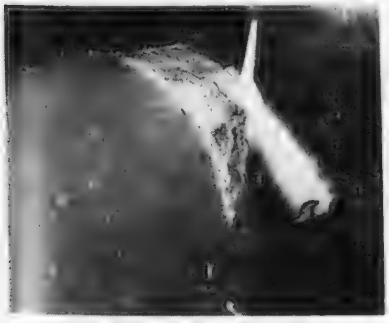
TURNING A HUGE REDWOOD CANT on one of the headrigs of the Union Lumber Company sawmill.

POWER PLANT of the Red Bluff Diamond Gardner operation. The engineered design of the burners, which reduces fly ash to a minimum, is a special feature.

Redwood Region

The trip to the Union Lumber Company's operation at Fort Bragg will offer a unique opportunity to travel through redwood forests and along the scenic Mendocino coastline. Union Lumber Company, one of the large redwood operations, owns over 171 thousand acres of redwood and Douglas fir timberlands, which are managed on a sustained yield basis. The company has had a long history, starting as the Fort Bragg Redwood Company in 1885. The visitor will see the tremendous redwood logs, which are cut into the many famous redwood products on the large band mills. All logs going into the mill are barked by a hydraulic log barker, which is of tremendous size in order to process the large redwoods. Also at Fort Bragg, the company has an historic museum in which are displayed equipment, pictures, and artifacts showing the story of lumbering, logging, and transportation in the Mendocino coast area since its inception in 1852.

A LOAD OF REDWOOD LOGS (5 to 6 feet in diameter) ready for transport to the Union Lumber Company mill at Fort Bragg. Load scales 17,000 bd. ft. (Humboldt scale).



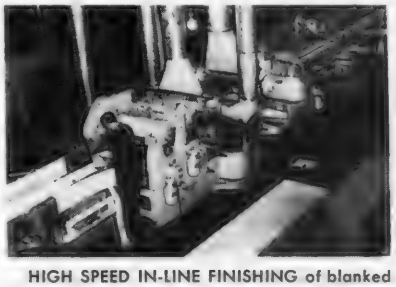
HYDRAULIC LOG BARKER at the Union Lumber Company can handle the largest redwood log.

Masonite Plant

The Masonite Corporation, Ukiah, is located on the edge of the coastal redwood belt and in the heart of the Douglas fir region of California. However, in traveling to Ukiah along Highway 101, evidence of agriculture is much more prominent than forestry operations. The Masonite Corporation, with main offices in Chicago, Illinois, consists of nine domestic plants and five foreign affiliates. The two hardboard producing plants of the company are located at Laurel, Mississippi, and Ukiah, California. The Ukiah operation consists of a complete hardboard manufacturing concern. Adjacent to the operation, the corporation owns a 70 thousand acre tree farm consisting of redwood and fir timber. However, at present, the plant does not use any timber but obtains its raw material from waste wood chips generated by sawmills in the surrounding area. The Masonite plant at Ukiah, one of the largest industries in the North Coastal Area of California, employs 625 persons. Each year, approximately 250 million square feet of hardboard, on a $\frac{1}{8}$ inch basis, are produced. The visitor will have an opportunity to see how chips are converted into fiber and the fiber, in turn, converted into hardboard on the two integrated manufacturing lines of the company.

Air Lift to Diamond Gardner

The new Red Bluff plant of the Diamond Gardner Corporation represents an investment of more than $25 million. Recently completed, it includes a completely integrated operation with sawmill, pulpmill, and molded pulp plant. The Diamond Gardner Corporation owns a 220 thousand acre tree farm on the western slope of the Sierra Nevada, which supplies the raw material for the Red Bluff operation. Species include ponderosa, Jeffrey, and sugar pine; Douglas fir; and incense cedar. The sawmill, which is designed to handle logs from 6 inches to 6 feet in diameter, processes approximately 90 million board feet of lumber annually. Residuals from the sawmill are chipped and sent to the pulp plant for pulping and manufacture into molded pulp articles such as egg cartons and disposable plates. In planning the Red Bluff unit, Diamond Gardner management brought together all of the skills and knowledge of the engineer and the scientist. For those looking for new ideas, a trip to this recently completed operation is a must. Because of the distance from San Francisco, transportation by plane is required; consequently, reservations are limited and those interested in making this trip should sign up as soon as possible after reaching San Francisco for the meeting.



HIGH SPEED IN-LINE FINISHING of blanked stock is only one of many interesting features incorporated into the design of the new Diamond Gardner installation.

Booth and Table-top Exhibit Space Available At National Meeting

An important addition at San Francisco this year will be the booth and table-top wood industry exhibits. The display area will be on the second floor of the St. Francis Hotel, adjacent to technical session meeting room. Exhibit chairman Victor Roth reports the exhibits will open Sunday, June 28, and continue throughout the week.

Shown will be portable equipment, products, and photographic displays. A booth 8 by 8 feet rents for $200, and an 18 by 60 inch table top for $75.

BUSINESS TRENDS

Hardwood Plywood

Hardwood plywood imports have captured more than 50 per cent of the American market, the Hardwood Plywood Institute pointed out recently. The organization is seeking higher tariffs and an import quota under the "escape clause" section of the Trade Agreements Act. The Tariff Commission rejected a similar proposal in 1955 but has agreed to hold another investigation. The Commission has scheduled public hearings in Washington, D. C. beginning April 14.

NLMA Lumber Letter, Jan. 9

Forestry Budget

President Eisenhower's budget for the fiscal year beginning July 1, requests $128,910,000 for the U. S. Forest Service, a reduction of $6,787,000 from the current fiscal year. Timber management funds would be increased by $2.8 billion, while appropriations for roads and trails would be raised by $515,000. The timber management request would provide for the sale of 10 billion board feet and a cut of 8.7 billion board feet.

NLMA Lumber Letter, Jan. 9

Housing Starts

1958 closed with 1,200,000 new housing units started, the largest number since 1955 and well above 1957's total of 989,100 units.

Furniture

Total 1958 shipments reached a point 7 per cent below 1957, due mainly to December shipments, which were 15 per cent better than the same month in 1957. December orders were 21 per cent greater than in 1957 and moved total orders for 1958 from —7 per cent at the end of November to —4 per cent for the year total.

NAFM Statistical Report

Veneer Logs

The volume of veneer logs produced in 1958 is estimated at 3.5 billion board feet, slightly higher than 1957's 3.3 billion bf There has been an increase in softwood veneer log production and a small decline in hardwoods. In the last two decades, the production of softwood veneer logs has increased from 460 million board feet to an estimated 2.6 billion board feet. In contrast, there has been little change in the volume of hardwood veneer logs produced since the early 1940's.

FPRS–American Institute of Wood Engineering Join Forces

The Executive Board of FPRS met with officers of the American Institute of Wood Engineering (AIWE) in Chicago November 6, 1958, to consider proposals for a close, working affiliation between the two organizations.

A program of cooperation was adopted whereby membership in FPRS would be a pre-requisite for membership in AIWE; AIWE resources would be used, insofar as practical, to assist in the publication of scientific papers in the FOREST PRODUCTS JOURNAL; and AIWE would be invited to hold both an open technical session and business meeting at the time and place of each FPRS national meeting. FPRS will also provide all membership services normally available to FPRS members, and clerical assistance as required.

The working agreement is to extend over a two-year period, through the Society's 1959 and 1960 meetings, and is subject to review during FPRS' fall, 1960 executive board meeting.

The Institute was organized in June, 1958, and now numbers 140 members, all of whom are also members of FPRS. Officers of AIWE are: J. S. Bethel, President; H. O. Fleischer, Vice-President; R. L. Youngs, Secretary-Treasurer; A. F. Muschler, F. E. Dickinson and A. J. Panshin, members of the Board.

Plans for First Annual Meeting

The annual meeting of AIWE will be held at the St. Francis Hotel, San Francisco, on Sunday afternoon, June 28, and will combine a technical session and a business meeting. Tentative plans call for a maximum of one or two papers, allowing ample time for floor discussion. It is hoped that preprints may be mailed to the members one month before the meeting. The business session will include committee reports on membership, constitution, and official name for the organization.

Saw Logs and Lumber

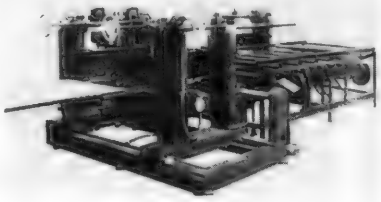
Saw logs and lumber produced in 1958 are estimated at about 2 per cent less than 1957 and 12 per cent less than 1956. The West accounts for about 54 per cent, the South 33 per cent, and the North 13 per cent.

The drop in production reflects a decrease in economic activity and continuing substitution of other materials for lumber.

Pulpwood

Pulpwood production in 1958 is estimated at 33.5 million cords including about 4 million cords of residues, about 3 per cent below 1957 and 5 per cent below 1956.

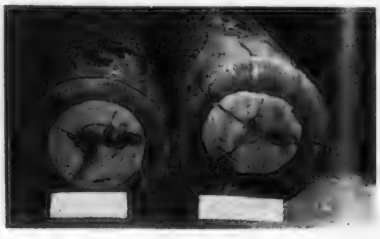
NEW PRODUCTS and Literature



New Continuous Feed Machines

A new Jenkins continuous-feed, double-end door or panel sizing combination has been announced by the Kohler-Joa Corp. The equipment consists of two model 192B double-end trim saws set at right angles to each other with an automatic transfer unit between the two.

The transfer unit has banks of driven and idling rolls that carry the rip trimmed stock just above the level of the feed chain travel of the cross trim unit. Top hold-down rolls are provided for plywood panel stock. The unit can be set up to handle a maximum of either 48-/or 60-inch-wide stock. More information is available from the Kohler–Joa Corp., Sheboygan Falls, Wis.



Strapping to Prevent End Checking

The application of strapping to prevent end checking and splitting of veneer logs has been announced by the Signode Steel Strapping Co. Signode reports that approximately one minute is required to apply one strap.

The method outlined suggests the logs be strapped after the log has been placed on a carriage and run through the drag saw operation. The ends of the logs are riding free, and the strap may be easily fed around the log.

According to Signode, the added material cost per log is less than 20 cents, which is far overshadowed by the increase in full-length face veneer. Complete information is available from Signode Steel Strapping Co., 2500 North Western Avenue, Chicago 47, Ill.

What's New in *Technical Publications*

1959 Western Pine Assoc. Directory. Lists 400 Western Pine Region lumber manufacturers and the products they make available. Contains mill locations, sales offices, species, branding, kiln drying facilities, staple products, special products, packaged paneling, and so forth. Available from the Western Pine Assoc., 519 Yeon Building, Portland 4, Oregon.

How to Design Pole-type Buildings. Donald Patterson. A working manual written for engineers. Gives design procedures for proportioning structural members of pole-type buildings of various sizes, kinds and uses. Available at $1.50 from the American Wood Preservers Institute, 111 West Washington Street, Chicago 2, Ill.

Specifications for the Pressure Treatment of Western Woods. Compiled from the Manual of Recommended Practice of the American Wood Preservers' Assoc., and contains the revisions covering wood preservatives, fire-retardants and methods. Available from the Western Wood Preserving Operators Assoc., 1410 S. W. Morrison Street, Portland 5, Oregon.

The following publications are available from the Ottawa Laboratory, Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources, Ottawa, Ontario, Canada.

Durability of Urea-Formaldehyde and Casein Adhesives at Elevated Temperatures. E. G. Bergin. Contains a description of tests carried out to investigate the influence of elevated temperatures on glued joints made with casein and room-temperature-setting urea resins, and the results obtained. F. P. L. Technical Note. No. 8.

The Efficiency of Scarf Joints. A. P. Jessome. This is a report of investigations and findings on different types of scarf joints. F. P. L. Technical Note No. 9.

The Short-Log Bolter, Its Use in Conversion of Canadian Woods. W. W. Calvert. Discusses advantages or disadvantages that could result from the use of short-log bolters as primary converions units for the production of specialized lumber dimensions. F. P. L. Technical Note No. 10.

Spiral Grain in Wood. P. L. Northcott. Reprint from British Columbia Lumberman. Available from Forest Products Laboratories of Canada, Dept. of Northern Affairs and National Resources. Vancouver, B. C., Canada.

List of Publications. A listing of all publications now available from the Oregon Forest Products Research Center can be obtained by writing P. O. Box 571, Corvallis, Oregon.

EMPLOYMENT *Opportunities*

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E–333—Sales representative wanted for hardwood and softwood concentration yard in metropolitan New York Area. (Mar.)

E–334—Adhesives research supervisor for planning, developing, and administering laboratory research program on adhesives, gluing processes, and glued products. Must have BS in chemical engineering or chemistry. Research experience required and some experience in production of adhesives and gluing. (Mar.)

E–335—Manager for glue department wanted. Will be responsible for production of resin and protein glues, administration of glue sales, and technical services to firm's plywood and door plants. BS in chemical engineering or chemistry required. Should have experience with resin and protein glues and gluing processes. (Mar.)

E–336—Technical director needed to formulate and administer technical, quality control, process and product development, and programs to serve firm's lumber, plywood, door, acoustical, and insulating board operations. Advanced degree desirable. Experience should include product and process development, quality control, and technical aspects of production. (Mar.)

E–337—Graduate wood technologist wanted for engineering dept. of manufacturer of organs. Located in Chicago. Work involves investigation of new methods and materials for producing high quality woodwork. (Mar.)

Employment Wanted

No. 503—Quality control position desired by wood utilization major. Three summers experience with Forest Service. Was student trainee at USFPL. Experience in paint research laboratory. Desires Midwest or Northwest. Available March. (Feb.)

No. 513—Graduate with MS in wood technology available or employment in wood products industries early June. Prefers western states. (Mar.)

No. 516—Graduate from U. of Washington with BS in forestry available for employment August, 1959. Major was forest products with courses in quality control and wood utilization. Currently officer in U. S. Marine Corps. (Mar.)

No. 517—Position desired with American logging co. in tropics. Has 10 years experience with timber industry as area manager on timber extraction. Extensive knowledge of both hand and mechanical logging methods in Africa and Malaya. Has forestry education. Speaks Malay. Available for interview in United States or Canada. (Feb.)

No. 518—Position desired in sales, sales management, or management in wood products industry or associated chemical industries. Four years sales experience and M.S. in Forestry with wood products marketing option. (Feb.)

No. 520—Position desired with lumber company, pulp and paper company, or university, in the field of research, public relations, or teaching. Received M.S. in 1958. Has done summer work in various fields of forestry. Experienced as reporter-photographer for three years. (Feb.)

No. 522—Graduate in Timber Management, forest engineering and utilization wants research position in by-product or waste utilization. (Mar.)

No. 523—Graduate with B. S. in wood technology desires position in forest products sales. University training in sales and wood engineering fundamentals. Experienced in retail and wholesale lumber sales. (Mar.)

No. 529—Graduate with B. S. in wood technology desires position in wood products industries. Age 27. Background includes wood properties, wood chemistry, pulp and paper chemistry, and statistics. Available June. (Mar.)

No. 532—Graduate with B. S. in industrial education with minors in mathematics, wood utilization, and physical science desires employment in wood utilization industry starting in June. (Mar.)

No. 479—Technical or production position desired. Age 32. Holds a B. S. in Wood Technology and degree in forest engineering from German technical university. Has experience as plant superintendent. (Mar.)

WANTED MANAGER

Wood technologist with practical experience in production to manage modern wood working plant in East Tennessee. Applicant must have had several years practical experience in the direction of production and he must be able to assume responsibility so as to take complete charge of the operation. Because plant is highly mechanized, the ability to see that equipment is properly maintained is important. Salary and bonus in high four figure bracket. This is a good opportunity for a competent person.

Send replies to:

E-340, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
417 North Walnut Street
Madison 5, Wisconsin

Complete Service On Wood Preservatives!

TECHNICAL COUNSEL

A full staff of specialists with years of experience and complete laboratory facilities, ready to assist in every way.

ENGINEERING SERVICE

An experienced engineering department to help in planning, designing and installing new pressure-treating plants; modernizing old plants; selecting equipment to meet your specific needs.

WOODTOX Penta Preservative and Water Repellent

A clear, clean, non-staining treatment combining advantages of Penta plus resistance against swelling, warping, shrinking and other moisture damage. Meets NWMA and Western Pine Assoc. preservative standards.

PENTAchlorophenol WOOD PRESERVATIVES

Most satisfactory and permanent of all wood preservatives against decay, fungi, termites and other wood boring insects.

NOXTANE SAP STAIN CONTROL

Most effective, safe and economical treatment made for protection against sap stain fungi. Leaves wood bright and clear. Quick solubility, dustless, non-irritating. Won't damage metal equipment.

EQUIPMENT

Exclusive national sales agents for Efurd Machine & Welding Company, builders of Hurricane Debarkers, Peelers, Framers, Incisors, Trams, etc.

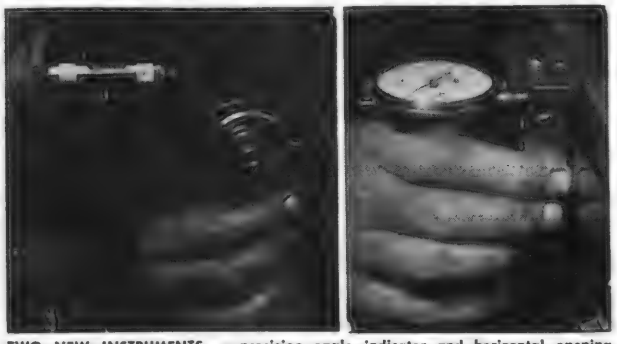
Whatever your problem in the protection and preservation of forest products, this is where you can always get the *right answers quick!* Write or phone.

WOOD TREATING

WOOD TREATING CHEMICALS CO.

5137 Southwest Avenue St. Louis 10, Missouri

NOW! Take the "Guesswork" Out of Veneer Cutting!



TWO NEW INSTRUMENTS, a precision angle indicator and horizontal opening indicator, eliminate "rule of thumb" methods for setting the angle of the knife and the horizontal opening between knife edge and nosebar on veneer lathe or slicer.

SINCE introducing these 2 new tools for precision cutting of veneers in January, they have been ordered and put into use in both softwood and hardwood veneer plants in every section of the U. S. and Canada — from British Columbia to South Carolina, from California to Ontario.

At a recent meeting one producer observed, "It doesn't make any difference how experienced the operator, there comes a time when he gets into trouble for some reason or other and he just can't get back. If he has some standards such as these instruments, they would help him correct his trouble."

With these instruments, even a novice can make accurate adjustments on lathe or slicer and cut good veneer consistently.

For literature and prices write:

WISCONSIN FOUNDRY AND MACHINE COMPANY

623 E. Main ST. Madison, Wis

Simpson land and plant resources are being managed for permanence in Washington, Oregon and California forest Committees

SIMPSON TIMBER COMPANY

Established in 1895

FPRS FOREST PRODUCTS JOURNAL
VOL. IX, NO. 2
FEBRUARY, 1959

PROBLEMS AND PRACTICES IN Wood Preservation, 1957-8

C. S. WALTERS[1]
Chairman, FPRS Wood Preservation Division

Problems confronting the industry, advances in methodology and materials, association activities, and items of general interest are presented this year. Foreign literature citations have been added.

Small installations such as this completely packaged Osmose pressure-treating plant, are gaining favor at sawmills and retail yards.

THE WOOD PRESERVATION INDUSTRY continued its progress in the fields of making wood more resistant to biological deterioration and fire and improving wood's service to tens of thousands of consumers. The industry can point with pride to its accomplishments during the past year, a period of economic adjustment.

More wood was treated with preservatives at commercial plants in 1957 than in 1956, according to statistics compiled by the U. S. Forest Service and the American Wood-Preservers' Association.

The report, based on information from 339 of the 358 known wood-treating plants, showed that 274.5 million cubic feet of wood were treated in 1957—16.6 million cubic feet more than in 1956.

Of wood treated, 102 million cubic feet were used for crossties. The rest of the treated wood was in poles, lumber and timbers, piling, posts, switch ties, crossarms, wood blocks, and miscellaneous items (listed in order of decreasing volumes).

In 1957, 179 million gallons of creosote and coal tar were used by treating plants—an increase of 4 per cent over 1956. Pentachlorophenol ranked first among the solid preservatives with about 12 million pounds used, a decrease of 9 per cent from 1956.

The wood preservation industry, its customers, and its competitors found it necessary to modify their operations the past year. Markets for crossties, for example, were depressed because of the critical position of the railroads. Although the utility pole market appeared to level off, the opportunities for selling poles for pole-type structures increased. An expanded highway construction program strengthened the markets for posts, piling, and other wood products. Farm markets generally were not given the serious consideration to which they are entitled. Although the opportunity to promote the use of treated wood through the revision of building codes has shown good promise, a logistical problem needs to be solved if the average homeowner is to find treated lumber readily available.

There is room for additional progress during the coming year. Education and product development are never-ending tasks, but they are the prerequisites to progress. The consumer of wood must be kept abreast of the industry's new developments. Technically trained personnel must be recruited to promote the existing programs and to develop new theories, methods, and materials that will assure the continuation of progress. Companies that accept the challenge of creating and expanding new markets will need to solve a host of production, personnel, and marketing problems, but their solution in many instances may mean the difference between failure and survival.

Application of Wood Preservatives

Pressure Methods: Very little work has been initiated in the United States to investigate the use of high pressures in the preservative treatment of wood. Most of the literature indicates that pressures above 200 psi result in near collapse and irregular penetration of the preservative. Australian investigators have reported, however, that certain dense species were treated with pressures as high as 1,000 psi without causing obvious damage to the wood. R. E. James, New York State University College of Forestry graduate student, treated red oak toughness specimens. (.79 by .79 by 11 inches) for one-half hour at 100° F. with creosote under pressures of 200, 500, 800, and 1,000 psi. Other specimens were treated at 200° F. under pressures of 200, 500, and

[1] This report could not have been prepared without the help of nearly 30 persons who contributed data or made suggestions for improvement. Their assistance is acknowledged with sincerest thanks.

The Author: C. S. Walters is Professor of Forest Utilization Research, University of Illinois Department of Forestry. He holds degrees from Purdue, New York State University College of Forestry, and Yale University. A charter member of FPRS, he is also a member of Sigma Xi, SAF, AWPA, and the Institute of Wood Engineering.

Increased pole-type construction bolstered treated-pole sales.

800 psi. Any strength losses resulting from the treatments were too small to be significant at a 0.05 confidence level when compared to untreated specimens. Although the results were shadowed by the possible masking effect of uncontrolled variables within the specimens, they indicate a possibility of shortening commercial treating schedules currently used.

Several small pressure-type treating plants were installed at sawmills and lumber yards for treating lumber by the Osmose process or with Celcure.

The J. Neils Lumber Co. has continued its work on the kiln drying of poles prior to preservative treatment, and a pilot kiln was placed in operation. Research continued on the seasoning and pressure treatment of poles with spiral grain with the expectation that the utilization of spiral grain trees will be improved and twisting of poles in service will be eliminated or reduced to an acceptable limit.

Studies of the steaming of southern pine poles and its effect on strength have been completed by the U. S. Forest Products Laboratory and the American Society for Testing Materials. A final report on the investigation is being prepared. Additional tests that have been initiated include treatments of southern pine poles with creosote and pentachlorophenol following steam conditioning under various schedules of temperature and time.

Non-pressure Methods: The Wood Preservation Council, formed by agencies in those states in which the Tennesse Valley Authority operates, initiated a series of lumber-treating investigations that included brush treating, 3-minute dip, and 15-minute cold soak. The treated lumber will be studied under exterior service conditions.

The U. S. Forest Products Laboratory initiated a study of the effectiveness of certain proprietary materials recommended for groundline treatment of standing poles. This investigation has been underwritten by one of the country's major utilities. Various types of groundline treatments were included in field tests started in 1957 at the Harrison Experimental Forest, Saucier, Mississippi; Ft. Collins, Colorado; and at Madison, Wisconsin. The applications were made on treated and untreated pole stubs of southern yellow pine and western redcedar, and on treated stubs of Douglas-fir, western larch, and lodgepole pine. Chemical analyses to determine the amounts of chemical at different depths and performance after a number of years of exposure are being used as methods of evaluating the various treatments.

Field tests of unseasoned posts treated by a double-diffusion method (a two-stage treatment in aqueous solutions of inorganic compounds is used to secure the precipitation of an insoluble, toxic compound in the wood) were installed by several agencies. Some difficulty was reported in securing treating vats that would not be corroded by one of the treating solutions.

A study of the factors affecting the soaking treatment of basswood at low temperatures was completed at the University of Illinois. Small test blocks were intermittently and continuously treated at five levels of solution temperature (80°, 40°, 20°, 10°, and 5°) and at four levels of wood moisture content (7, 12, 19, and 26 per cent) in solutions of pentachlorophenol prepared with diacetone alcohol and hexylene glycol. Absorption of solution was measured in each of 400 small test blocks, and concentration of the toxicant was measured at three depths in each of 80 groups of blocks. The results offer possible explanations for the variations reported in cold-soaking tests on fence posts and other wood products.

Test Methods for Preservatives

The industry recognizes that unqualified acceptance of its product and the resultant expansion of sales rests upon developing a test method by which the purchaser or any independent commercial testing laboratory can determine whether the treated product meets the purchaser's spcifications. Retention measurements have been determined from gage readings made before and after treatment. In the majority of cases, this method has been satisfactory or acceptable, even though the treater and the consumer would have liked to determine the amount of preservative solution left in the wood from measurements made on the product.

A symposium sponsored by the AWPA at its 1957 convention considered methods that would be useful in measuring the results of treatment after using a results-type specification. At the AWPA's 1958 convention, Baechler reported on a method of assaying marine piling by the extraction of borings. So far only poles and piling have been considered, but the method may be useful in assaying other types of products. One large utility company is adopting a results-type specification for southern pine poles treated with creosote, pentachlorophenol, and creosote-penta mixtures. Other companies are expected to follow the trend.

The Monsanto Chemical Co. and the Dow Chemical Co. have installed equipment for analyzing samples of wood treated with pentachlorophenol by the X-ray fluorescent spectra technique described by Wright and Sparks in the 53rd Proceedings of the AWPA. The technique requires only a fraction of the time needed for analyses by other methods.

Committee P–5 of the American Wood Preservers' Association presented a copper-pyridine method for the determination of pentachlorophenol in oil or wood. The method is suitable for chlorinated phenols with the exception of those that do not have both the 2 and 6 positions of the benzene ring occupied by chlorine. Such compounds give no color reaction.

Meek reported a new technique in which azo dyes were formed from simple phenols and a diazotized amine. He hypothesized that, if a sufficiently strong coupling agent could be used to displace a chlorine atom from the pentachlorophenol molecule, the formation of a dye would indicate the presence of the toxicant in wood.

The soil-block method for making accelerated laboratory tests of preservative chemicals, adopted in 1956 as a tentative standard (D–1413 56T) of the American Society for Testing Materials, was approved in 1957 without change for continuance as a tentative standard. The U. S. Forest Products Laboratory has obtained additional data during the year on the effect of species of wood on preservative threshold values determined by the soil-block method. The Laboratory also established additional field tests to study the degree of correlation between soil-block and field-test results.

Considerable progress has been reported by the American Society for Testing Materials on the standardization of the accelerated field stake test for evaluating preservatives. The standard probably will be confined to ¾-inch stakes.

New Preservative Chemical

Although the use of copper fluonate as a wood preservatives was reported earlier, it is interesting to note that

NON-COM treated Douglas-fir decking after 53 minutes of a standard fire test. The wood retained its load-bearing strength.

its use on an experimental basis has expanded during the past year. New investigations include tests of resistance, which copper-tolerant fungi often have to copper-containing preservatives.

The Dow Chemical Co. announced the development of an oil-soluble fire retardant, Arban, for the treatment of wood. Arban, a triphenyl phosphate derivative, has little if any value as a wood preservative. Since it is soluble in oil, however, it can be incorporated with some types of preservative solutions. The new compound is under test in railroad trestle timbers and fence posts.

Zabel, New York State University College of Forestry, Syracuse, reports that evaluations of organic arsenicals as toxicants and slimicides show that compounds such as 8-hydroxyquinoline arsanilate, 8-hydroxyquinoline methyl arsonate, silver cacodylate, and methyl arsine oxide have demonstrated considerable fungicidal activity.

Fahlstrom reported on his evaluation of the preservative properties of organotin compounds by soil-block techniques.

Regional Activities

Northeast: The New York State University College of Forestry, Syracuse, reports that stake and boardwalk installation tests at Syracuse and Gainesville, Florida, designed to evaluate a group of common soil-soluble wood preservatives for the U. S. Army, are now in their third year of exposure. A progress report presenting the present status of the study by Ray Moore and Robert Zabel is being prepared for publication. The results to date emphasize the great differences between the severe decay hazard of wood in contact with soil as contrasted to wood exposed a few inches above the ground. No decay has developed in the pressure-treated series, whereas extensive failures have occurred in the dip-treated stakes in ground contact and all untreated controls. Important differences in the effectiveness of the preservatives are apparent, with 5 per cent pentachlorophenol, 2 per cent copper naphthenate, and 7.5 per cent rosin amine D pentachlorophenate appearing to be the most effective preservatives in these tests.

Dr. Zabel also is investigating the relative durability of eastern white pine to determine whether major tree or wood characteristics can be correlated with decay resistance. This study is supported by the U. S. Forest Service. Sharp differences in the durability of wood from different white pine trees and in wood from various radial positions in the heartwood already are apparent.

Marine installations have been doing reasonably well, particularly along the eastern seaboard, but the developments have lagged in the harbor developments in the Great Lakes Seaway route. Some cities have established port commissions or have retained the services of consulting engineers to plan piers and dock facilities. Duluth, Cleveland, and Chicago have made plans that will require the use of treated piling and lumber. Many of the smaller lake cities, however, are not planning to refurbish old and long-idle harbor facilities until they are able to gage the amount of traffic that will develop as a result of the Seaway.

A symposium on the problems related to marine piling was held at the William F. Clapp Laboratories, Inc., in Duxbury, Mass., in May 1958 in conjunction with the spring meetings of the AWPA Preservatives Committees. A discussion of the problems involved in the selection of proper preservative specifications, as well as plant and production problems, was held in an effort to improve the service life of wood piling.

North Central: Kansas State College, Manhattan, reports that a graveyard has been established to test pine and oak stakes treated with various commercial brands of pentachlorophenol.

South Central: The cold-soak treating plant installed by the University of Tennessee at the Ames Plantation in 1956 now furnishes treated lumber for farm buildings and bridges for field stations of the Agricultural Experiment Station. The installations demonstrate to local farmers and to groups visting the experimental areas the value of home treatment.

The University of Missouri School of Forestry, Columbia, has expanded its fence post treating investigation to include identification of the fungi and insects responsible for the deterioration of posts.

Several small pressure treating plants that use Osmosalts have been installed in Missouri, Kentucky, and other midwestern states.

Dierks Forests, Inc., Hot Springs, Ark., has offered lumber dipped in water-repellent solutions at no additional cost to the consumer as a means of stimulating lumber sales. A number of other companies supply a similar service to customers, but charge for the treatment.

South and Southeast: An increasing number of small pressure plants have been installed by southern sawmills and lumber yards to treat lumber with Osmose salts. The firms that have undertaken the pressure-treating work have specialized in the production of paintable lumber for local distribution. They report very good markets for their products.

The University of Florida's School of Forestry reports that reduced checking and satisfactory preservative treatment have resulted from kiln-drying of gum crossties, and the results for oak hickory ties appear to be promising.

Rocky Mountain and Inland Empire: Despite a general weakening in markets in other fields, the demand for treated wood products in the southern part of the Rocky Mountain region held at a level comparable to previous years. Pole demands were somewhat spotty principally during the forepart of the period. This was more than offset by increases in building poles and fence posts. The fence-post market was unusually strong.

Two new pressure-treating plants came into production during the period. One of these plants, which was reported as under construction earlier, is located at Eagles Nest, New Mexico, and is operated by Lebus Brothers. It is a two-cylinder unit with capacity to treat poles and posts. It will draw on native ponderosa pine and Douglas-fir for raw material. The other plant is located at Sturgis, South Dakota, and consists of a single cylinder designed for posts and small poles. It is owned and operated by the J. U. Dixon firm, which also operates a sawmill at that location.

Research facilities for wood preservation received a real boost during the year with the installation of an experimental pressure-treating cylinder at Colorado State University's School of Forestry. This was done under the direction of Professor Harry Troxell and has greatly stimulated interest in the preservation field.

Satisfactory treatment of Engelmann spruce, thin-sapwood lodgepole pine, and inland Douglas-fir remain the number one problems in research.

The groundline-treating processes, designed to bolster treatments that are showing premature failure, are receiving considerable attention at the present time. A test plot of 135 poles, consisting of the major, pole species, was installed in the Fort Collins area for the purpose of studying the effectiveness of these methods. The work is being done cooperatively by the Forest Products Laboratory, Rocky Mountain Forest Expansion Station, a number of wood-preserving chemical manufacturers, and Colorado State University's Forestry School. Matched plots were also installed at Madison, Wis., and the Harrison Experimental Forest, Saucier, Miss.

The groundline-treating method is already receiving considerable use in the general area. The work is being contracted by both public and private utility firms, and a large number of poles have been treated in place.

Despite the severe reverses that have plagued most of the forest industries the past year, the pole industry has done quite well in the Northern Rocky Mountain region. Reports by the U. S. Forest Service indicate that the 1956 production of poles was 96 per cent over that for 1955 and 108 per cent above that for 1954.

Two developments partially account for this success: a cleanup of back orders by utility companies and the Rural Electrification Administration, and the sudden expansion and growth of pole-frame construction. It is in the second area that the most promise occurs. As more and more builders learn of pole-frame construction and the substantial cost savings involved, still greater use can be expected. This use is tailor-made for the Rocky Mountain species, particularly lodgepole pine.

Pacific Coast: Staff members of the former Oregon Forest Products Laboratory moved to new facilities in a modern all-wood building near the Oregon State College campus. The wood-treating work at the Forest Products Research Center will be expanded as a result of the addition of a small laboratory for analyzing preservative content of treated specimens.

Work under way or completed at the Center during the past year included:

1. Marine exposure tests of Douglas-fir and southern pine panels treated with creosote, creosote-coal tar, Chemonite, and copper formate, initiated at Friday Harbor, Wash.; San Francisco and Los Angeles, Cal.; Virginia Keys and Daytona Beach, Florida; and at Boston, Mass.
2. Kiln-drying and pressure treatment of round West Coast hemlock.
3. Treatability of Douglas-fir heartwood.
4. Strength of fire-retardant-treated wood.
5. Evaluation of penta spray treatment of western redcedar poles in service.
6. Evaluation of treated material; serviceability of posts with a wide range of treatments, nonpressure-treated green poles, and greenhouse seed flats; corrosion of metal fastenings in treated wood.

A symposium in marine biology was held at Friday Harbor Marine Laboratory, University of Wash., in Sept. 1957. Topics discussed included: Limnoria, Terediniens, barnacles, cellulases, and the economic implications and evaluations of these subjects. Fundamental research reviewed at this symposium will lead to a better understanding of causes and nature of deterioration of wood in marine waters as well as to improved methods for preserving wood in marine structures.

Eastern Canada: Construction of a new building for the Ottawa Laboratory, Forest Products Laboratories of Canada, was completed, and the staff moved in during April 1958. Most of the heavy equipment is installed and is working. During the past year, soil-block tests with the copper-tolerant fungus *Poria monticola* showed that copper abietate was very effective in preventing decay, but that copper formate, fixed in the wood by a heat treatment, offered very little protection against decay. Both copper abietate and copper formate were found to be resistant against leaching by water. Both preservatives were pressure impregnated into fence posts for long-term service tests in the Laboratory fence-post test plot. The copper formate was very corrosive to the treating retort and piping.

Investigations were continued on the nonpressure treatment of green fence posts by sap displacement, a method suitable for farmers to use on material from their own woodlot. A water-soluble salt preservative of the "fixing type," acid copper chromate, was used and treatments were considered very satisfactory. It is desirable to store the posts for at least two months to permit the preservative to become insoluble and resist leaching action. It is undesirable to have large seasoning checks open up and expose untreated wood, however, so would be best to store the treated posts in a close pile, covered from the sun and rain.

In cooperation with a large Canadian railroad, soil-block tests were carried out to determine the effectiveness of pentachlorophenol in several western Canadian heavy residual petroleum oils. As a result, the railway has decided to treat a number of its ties with the most suitable of the mixtures.

A new pressure-treating plant was built in Manitoba during the past year. It is intended to specialize in the Cellon treatment of lumber, mine timbers, and fence posts with Boliden salts of the newer type.

Western Canada: Construction of new laboratory facilities for the Vancouver Branch, Canadian Forest Products Laboratory, was started in 1957. The new building, located in a naturally wooded area, will provide additional space and facilities for wood preservation research. The results of an investigation of the Boulton process for seasoning wood prior to pressure treatment with preservatives were reported in the FOREST PRODUCTS JOURNAL in June 1957. Factors affecting the ratio of naphthalene and water in condensate of a boiling-under-vacuum system also were investigated by the Canadian Laboratory. The effect of marine borers on wood in British Columbian waters was studied, and a report has been submitted for publication. The report discusses requirements of marine piling, protective devices and treatments, service record in British Columbian waters and an evaluation of early failures, and the biology of *Bankia setacea* and *Limnoria lignorum*. An annotated bibliography of 100 entries completes the report. The Laboratory is continuing its work on factors that affect the penetration of oil-type preservatives in mountain-type and coast-type Douglas-

Amount of penta in wood can be determined in 3 minutes by X-ray spectrograph at Monsanto.

This timber bulkhead cost $54,600 *less* than alternate stone; maintenance is also less. Photo courtesy AWPI.

fir with emphasis on anatomical characteristics.

Association Activities

The Wood Preservation Division, Forest Products Research Society, held a technical session at the 1958 annual meeting in Madison, Wis. The theme was "Improving the Competitive Position of Wood Through Treatment." Five papers were presented, including reports on the treatment of packing boxes, millwork, and particle board; improving wood's durability through chemical modification; and the "preservation" of markets through treatment. Members are arranging a technical session for the 1959 annual meeting of the Society in San Francisco.

The American Society for Testing Materials continued its strength tests of full-scale treated and untreated southern yellow pine, western redcedar, lodgepole pine, Douglas-fir, and western larch poles. The study will encompass some 600 full-size poles and 15,000 small, clear specimens cut from the poles. The cost of the project will be in the neighborhood of a quarter-million dollars, but it will provide data that has heretofore been unavailable.

The American Standards Association and the Cooling Tower Institute are working on problems that concern the deterioration of wooden cooling towers.

The American Railway Engineering Association initiated a study on the prevention of termite attack. Red oak, Douglas-fir, and southern yellow pine test stakes have been installed at the University of Florida. Each species of wood was treated with three different retentions of creosote, chromated zinc chloride, tantalith, pentachlorophenol, copper naphthenate, acid copper chromate, ammonical copper arsenite, chromated zinc arsenate, and chromated copper arsenate. The Association also reported that pressure preservation has increased the average service life of railway ties from 7½ to 38 years.

The National Fire Protection Association has developed the first draft of a standard for fire-retardant wood.

The American Wood Preservers Institute reported that the pole-type structure that has become so popular with farmers is being used by commerce and industry for warehouses, garages, machinery storage, and manufacturing facilities. Building codes are being changed in a number of cities to permit the erection of this type of building. The Institute has taken an active part in the Interstate and Intrastate highway program, working with the American Association of State Highway Officials, the U. S. Bureau of Public Roads, the U. S. Forest Service, and the U. S. Bureau of Reclamation. The Institute has assembled data and presented evidence that there is no logical justification for the common belief that concrete piles rate greater design loads than do wood piles. As a result, there has been an increase in the use of pressure-treated timber foundation piles.

The AWPI's 68-page bulletin, "How to Design Pole-Type Buildings," was prepared to aid the designers. The basic design has been accepted by the Southern Building Code and approved by the Research Committee of the International Conference of Building Officials. Hence with the acceptance by two basic codes, the AWPI believes that pole-type buildings eventually will be accepted by the building codes of hundreds of communities throughout the country.

The 1957 Survey of Current Research of Interest to the Forest Products Industry of the United States, published by the National Lumber Manufacturers Association in October 1957, is a highly useful contribution to the literature on forest products research.

A group of persons interested in the fundamental and applied aspects of marine deterioration, who formerly met annually at Wrightsville, North Carolina, as the Marine Borer Conference, has received official sanction as Committee T-9 of the National Association of Corrosion Engineers. The committee will keep the association informed of research and advancements in the specialized field of deterioration of wood by the action of marine organisms and its prevention. The first meeting of the T-9 committee was held in San Francisco in connection with the 1958 annual meeting of the NACE, and a program of technical papers was scheduled. The committee will meet in June 1959 at Wrightsville, North Carolina, in conjunction with the Sea Horse Institute meetings.

The Douglas Fir Plywood Association announced that limited tests have been made on flame-spread resistance of a few proprietary paints in accordance with Federal Specification SS-A-118b.

The American Institute of Timber Construction has begun work on specifications for gluing treated wood and treating glued wood. The standard is expected to be finished in 1958.

The Western Wood Preserving Operators' Association has continued its efforts to have pressure-treated wood included in specifications and building codes where wood has been excluded previously. Emphasis was placed on utilization of wood in highway construction and on the use of rigid pillar construction both in industry and on the farm.

The Building Research Advisory Board (BRAB) committee on "A Study of Protection Against Decay and Termites in Residential Construction" prepared an addendum to their 1956 report[2] which defined two additional problems:

[2] NAS-NRC Publication 448, Building Research Institute, National Research Council, Washington, D. C., 1956.

1. A determination of amounts of preservative-treated wood necessary to provide adequate protection against termites for various types of construction and in various geographical locations.

2. A determination of the effectiveness of various vapor-barrier materials in preventing decay when placed between masonry foundations and sill plates.

The majority of the Committee recommended that all wood in a house be treated to achieve "positive protection." Recommendations for "minimum protection" were included in the Committee's 1956 report. The Committee concluded that a vapor barrier placed between masonry foundation walls and the sill plate was an unsatisfactory decay prevention measure.

Bibliography

Continental United States

Alpen, R. M. 1958. Wood preservation on the Southern Pacific. Proc. AWPA 54: 98–102.

Anderson, A.B., E. Zavarin, and T. C. Scheffer. 1958. Nature of some decay-retardant extractive components in incense cedar (*Libocedrus decurrens* T.) heartwood. Nature 181 (4618): 1275–76.

American Wood Preserves Institute. 1957. How to specify and use pressure treated wood for highways. AWPI, Chicago, Ill.

AWPA. 1957. Pole construction makes good business. Wood Preserving News 35 (6): 6–8, 10.

AWPA. 1957. Wood minehunter to join fleet. Wood Preserv. News 35 (6): 24–26.

AWPA. 1957. Master pile driver—A. E. Whitney. Wood Preserv. News 35 (7): 8–10, 12.

AWPA. 1957. An open letter to the F.H.A. Wood Preserv. News 35 (8): 5–7, 10, 20.

AWPA. 1957. Chicago's Congress Street expressway. Wood Preserv. News 35 (8): 14, 16.

AWPA. 1957. Building a timber dam to last. Wood Preserv. News 35 (9): 10–11.

AWPA. 1957. Volume of treated wood rises again. Wood Preserv. News 35 (9): 12, 14.

AWPA. 1957. Great Lakes Naval Barracks suffer severe decay. Wood Preserv. News 35 (10): 16–18.

AWPA. 1957. Tornados lay bare decay of foundation lumber exceeding strom damage. Wood Preserv. News 35 (11): 6, 10, 12.

AWPA. 1957. Nursery switches to preservative treatment when durable wood fails. Wood Preserv. News 35 (12): 18.

AWPA. 1957. Termites infest Chicago homes. Wood Preserv. News. Part I, 36 (1): 8–10. Part II, 36 (2): 12–14.

AWPA. 1958. Timber poles support 96-ton load in Gulf Coast area. Wood Preserv. News 36 (3): 5–7.

Anon. 1957. Poles furnish cheap support. Chem. Eng. 64 (6): 168, 170.

Anon. 1957. Timber trestles with built-in fire protection. Railway Track & Structures 53 (6): 39–41.

Anon. 1957. UCLA, Purdue termite research suggest new control methods possible, NPCA convention hears. Pest Control 25 (12): 16, 18, 20, 30.

Anon. 1957. Proceedings of the Third Northeastern Wood Preservation Conference. Bul Northeastern Wood Utilization Council, No. 45 ($3.00).

Anon. 1958. Fluorescent cloverleaf. (Fort Wayne, Ind., uses fluorescent lighting at highway interchange.) Public Power 16 (1): 14–15.

Anthony, Sam. 1957. Navy housing 'shipshape' after 16 years, thanks to treated lumber. Wood preserv. News 35 (11): 7–8.

Baechler, R. 1958. Determination of retentions of oil preservatives in heavily treated piling by the extraction of borings. Proc. AWPA 54: 34–43.

Baechler, R. 1958. How to treat fence posts by double diffusion. Forest Prod. Lab. Report 1955. Madison, Wis.

Baltuth, O. 1958. Indiana Highway Department lightens night accident toll. Wood Preserv. News 36 (3): 8–10.

Becker, G., and G. Theden. 1957. Annual report on wood protection: 1955. Phytopath. 47: 752.

Blew, J. O. 1957. The preservative treatment of wood for farm use. U.S.D.A. Forest Prod. Lab. Report 2098. Madison, Wisconsin.

Blew, J. O. 1957. Forest Products Laboratory research. Rail. Purch. & Stores 50 (5): 116–120.

Blew J. O. 1958. Comparison of wood preservatives in stake tests (1958 Progress Report) U.S.D.A. Forest Products Laboratory Report 1761. Madison, Wis.

Blew, J. O. 1958. Symposium on methods of conditioning wood prior to preservative treatment. Proc. AWPA 54: 55–76.

Blew, J. O., and J. W. Kulp. 1958. Comparison of wood preservatives in Mississippi post study. Forest Prod. Lab. Report 1757. Madison. Wis.

Bond, W. R. 1957. How to cover a reservoir. Wood Preserv. News 35 (6): 19–20.

Bond, W. R. 1957. Pressure treated glulam girders. Wood Preserv. News 35 (10): 20.

Boyd, J. S. 1957. Clear-span pole buildings. Wood Preserv. News 35 (7): 18–20, 22.

Carter, H. G. 1957. How railroads can get long life from cross ties of gum. Cross Tie Bul. 38 (6): 14, 16, 20.

Coburn, S. K., and K. J. Morris. 1958. Some effects of creosote solutions on the flammability of southern yellow pine. Proc. AWPA 54: 78–97.

Colley, R. H. 1957. Marine biology and commercial treating. Wood Preserv. News 35 (12): 6–8.

Conners, W. M., and G. Bramhall. 1957. An evaluation of factors affecting the rate of drying of round western hemlock. Forest Prod. Jour. VII (6): 205–208.

Coordinated Wood Preservation Council. 1957. Annual Reports of cooperating agencies in the southeast. Forestry Division, Tenn. Valley Authority, Norris, Tenn.

Cowling, E. B. 1957. The relative preservative tolerances of 18 wood-destroying fungi. Forest Prod. Jour. VII (10): 355–395.

Duncan, C. G. 1958. Evaluating wood preservatives by soil-block tests: 10. Effect of species of wood on preservative threshold values. Proc. AWPA 54: 172–177.

Ebeling, W., and R. J. Pence. 1957. Relation of particle size to the penetration of subterranean termites through barriers of sand and cinders. Jour. Econ. Ent. 50 (5): 690–692.

Ebeling, W., R. J. Pence, and R. E. Wagner. 1958. UCLA termite research with chemical physical barriers; inert diluents. Pest Control 26 (3): 50, 52.

Fahlstrom, G. B. 1958. Organotin compounds: Evaluation of preservative properties by soil-block techniques. Proc. AWPA 54: 178–184.

Garlick, G. G. 1957. Treated lumber is insurance for the builder. Practical Builder (4): 199–200.

Giles, D. T. 1957. New tobacco barn to resist hurricane. Wood Preserv. News 35 (11): 13, 15, 19.

Giles, D. T. 1958. Problem—heavy beach erosion at Naval Station. Solution—low-cost timber bulkhead. Wood Preserv. News 36 (1): 12–14.

Gillespie, R. F. 1958. Boaters flock to new Coos Bay marina. Wood Preserv. News 36 (2): 8, 10.

Graham, R. D., and D. J. Miller. 1958. Full-cell treatment of kiln-dried Douglas-fir crossties with creosote and creosote-coal tar. Oregon Forest Prod. Lab. Report P–4.

Graham, R. D., and O. J. Miller. 1958. Kiln drying and pressure treatment of round west coast hemlock. Proc. AWPA 54: 215–222.

Hamilton, L. S., and G. R. Cunningham. 1957. Longer life for wood in your fence lines and vineyards. Cornell Agr. Ext. Bul. 987: 1–24.

Hartley, Carl. 1958. Biological factors influencing the effectiveness of wood preservatives against decay. Applied Microbio. 6 (3): 207, 211.

Hatfield, Ira. 1958. Wood destroying organisms. Part I: Composition and structure of wood. Pest Control 26 (2): 26, 28, 31. Part II: Recognition of organisms—control methods and materials. Pest Control 26 (4): (Pages not yet assigned). Part III: Application of knowledge covering control procedure. Pest Control 26 (6): (Pages not yet assigned).

Hatfield, Ira. 1958. Report on wood preservation activities—1956–57. Forest Prod. J. VIII (2): 58–62.

Hatfield, Ira, and R. G. Van Allen. 1958. Studies of pentachlorophenol motility in relation to solvent translocation. Part I. Evaporation rate and residual content of penta-petroleum preservative solutions outside of wood structure. Proc. AWPA 54: 23–33.

Holmes, E. I. 1957. Trials with laminated crossarms. Forest Prod. J. VII (11): 26-A-29A.

Hossfeld, R. L., J. C. Oberg, and D. W. French. 1957. The appearance and decay resistance of discolored aspen. Forest Prod. J. VII (10): 378–382.

Huber, H. A. 1957. Treated-pole hardness tested. Electric Light & Power 35 (20): 110–111.

Huffman, J. B. 1957. The kiln drying of gum crossties. Proceedings AWPA 53: 163–178.

Huffman, J. B. 1958. Kiln drying of southern hardwood crossties. Forest Prod. J. VIII (6): 165–172.

Huffman, J. B. 1958. Kiln drying of crossties. Wood Drying Division, FPRS News Digest. March.

Isherwood, H. R. 1957. Pressure-treated wood tops shields in home mechanical termite control. Pest Control 25 (1): 32, 34.

Jennison, M. W., C. G. Richberg, and A. E. Krikszens. 1957. Physiology of wood-rotting Basidiomycetes. II. Nutritive composition of mycelium grown in submerged culture. Appl. Microbiol 5 5 (2): 87–95.

Johnston, H. R. 1958. Tests with soil poisons for controlling subterranean termites. Pest Control 26 9, 11–16.

Johnston, H. R., R. H. Smith, and R. A. St. George. 1958. Control of *Lyctus* powderpost beetles in lumber yards and processing plants. Pest Control 26 (1): 41–42.

Kelly, W. C., Jr., and E. A. Behr. 1957. Effect of final steaming on distribution and permanence of pentachlorophenol in air-seasoned southern yellow pine pole sections pressure-treated with pentachlorophenol-petroleum. Forest Prod. J. VII (6): 178–186.

Kleinhoff, G. G. 1957. A new method for testing treated wood specimens. Forest Prod. J. VII (9): 20-A–21-A.

Leuschtz, J. 1957. Bleeding of oil-type preservatives. Bell Laboratories Record 35 (7): 252–255.

Linderen, R. M., and E. C. O. Erickson. 1957. Decay and toughness losses in southern pine infested by *Peniophora*. Forest Prod. J. VII (6): 201–204.

Lund, A. E. 1957. An accelerated wood-preservative termite study. Forest Prod. J. VII (10): 363–367.

Lund, A. E. 1958. The relationship of subterranean termite attack to varying retentions of water-borne preservatives. Proc. AWPA 54: 44–53.

Mann, R. H. 1957. Atlantic City building modern marina. Wood Preserv. News 35 (7): 14, 16–17.

Mann, R. H. 1957. Marine piles 68 years old still sound. Wood Preserv. News 35 (10): 6–7, 10.

McKnight, T. S. 1957. Some physical factors influencing the effectiveness of preservatives. Forest Prod. J. VII (12): 441–444.

Meek, W. L. 1958. Paper partition chromatography of chlorinated phenols. Univ. Ill. Agr. Exp. Sta. For. Note 75.

Menzies, R. J., and Ruth Turner. 1957. The distribution and importance of marine wood borers in the United States. ASTM Special Tech. Pub. 200. pp. 3–21. Philadelphia, Penn.

Miller, D. J., and R. D. Graham. 1957. Seasoning and preservative treatment of tanbark oak lumber. Oregon Forest Prod. Lab. Report P-3.

Miller, D. J., and R. O. Graham. 1957. Full-cell treatment of kiln-dried coast-type Douglas fir piling with creosote and creosote-coal tar. Oregon Forest Prod. Lab. Report P-2.

Moore, R. F. 1958. A modern low-cost church. Wood Preserv. News 36 (3): 12, 14.

Norum, W. A. 1957. Treating redwood pays off. Wood Preserv. News 35 (12): 14, 16.

Norum, W. A. 1957. California state architects build for permanence. Wood Preserv. News 35 (8): 12–13, 24–26.

Nuechterlein, D. C., and J. H. Secor. 1957. Treated farm posts—their sales in a test area. Forest Prod. J. VII (9): 18-A–20-A.

Osborne, R. L. 1957. Largest pole warehouse—2.9 acres. Wood Preserv. News 35 (10): 12, 14, 23.

Osborne, R. L. 1958. Alabama Power Co. to extend transmission lines. Wood Preserving News 36 (2): 6–7.

Panek, E. 1957. Preservative treatment of jack pine and longleaf pine posts by the hot-and-cold bath and its boiling-in-water adaptation. U.S.D.A. Forest Prod. Lab. Report 2085. 10 pp. Madison, Wis.

Panek, E. 1957. Influence of fungus infection associated with chemipeeling of pressure impregnation and cold soaking of jack pine posts. Forest Prod. J. VII (4): 124–127.

Panel Discussion. 1957. A practical approach to the prevention of decay and termites in building construction. Forest Prod. J. VII (6): 23-A–28-A; VII (7): 19-A–23-A.

Prettie, R. J. 1957. New applications for preservative treated wood. Forest Prod. J. VII (9): 22-A.

Putnam, R. B. 1957. How and what to specify in the preservative treatment of wood for buildings. Forest Prod. J. VII (10): 360–362.

Radzikowski, H. A. 1958. Pressure treated wood and the U. S. highway program. Proc. AWPA 54: 103–110.

Ray, D. L. 1958. Recent research on the biology of marine wood borers. Proc. AWPA 54: 12–22.

Richards, A. P. 1957. Marine exposure tests of wood treated with various preservatives. ASTM Special Tech. Pub. 200. pp. 22–26. Philadelphia, Penn.

Roe, T., H. Hocman, and E. R. Holden. 1957. Performance tests of heavy metal compounds as marine borer inhibitors. ASTM Special Tech. Pub. 200. pp. 29–32. Philadelphia, Penn.

Rogers, R. T., and W. C. Kelso. 1958. The distribution of pentachlorphenol in pressure treated southern pine poles. Proc. AWPA 54: 162–171.

Rosen, H. J. 1958. Protection against decay and termites. Prog. Architecture 39 (1): 127.

Sakornbut, S. S., and R. J. Balske. 1957. The effects of soil, moisture, and aeration variables in bioassay by the soil-block culture method. Forest Prod. J. VII (11): 404–407.

Scheffer, T. C. 1957. Decay resistance of western redcedar. Jour. For. 55 (6): 434–442.

Scheffer, T. C. 1958. Control of decay and sap stain in logs and green lumber. Forest Prod. Lab. Report 2107. 13 pages.

Shenefelt, R. D., M. J. Stelzer, T. A. Pascoe, and F. G. Kilp. 1958. Spraying jack pine logs. Agricultural Chemicals 13 (1): 38–40.

Stacey, W. A. 1957. How to build good highway fences. Wood Preserv. News 35 (9): 6–8.

Stacey, W. A. 1957. Creosoted box culverts strong, durable, flexible. Wood Preserv. News 35 (11): 16–18.

Stacey, W. A. 1957. Good practice in pile driving. Wood Preserv. News 35 (12): 10–11.

Stacey, W. A. 1958. Pole construction is just beginning. Wood Preserv. News 36 (1): 6, 18–19.

Vind, H., H. Hockman, J. Muraoka, and Joan Casey. 1957. Relationship between *Limnoria* species and service life of creosoted piling. ASTM Special Tech. Pub. 200. pp. 35–49. Philadelphia, Penn.

Walters, C. S. 1958. Soaking treatment of basswood at low temperatures—as affected by temperature and viscosity of solution, wood moisture, and type of treatment. Univ. Ill. Agr. Exp. Sta. Sta. Bul. 633. Urbana, Ill.

Walters, C. S. and K. R. Peterson. 1957. Report on Project 301–A. Preservative treatment of fence posts by cold-soaking in pentachlorophenol—fuel–oil solutions. Univ. Ill. Agr. Exp. Sta. For Note 70.

Walters, C. S., and K. R. Peterson. 1957. The preservative treatment of electric fence stakes. A 10-year ad interim report on Project 55–331B. Univ. Ill. Agr. Exp. Sta. For. Note 74.

Walters, C. S., and K. R. Peterson. 1957. Report on Project 301–C. Preservative treatment of fence posts with toxic oil solutions by cold-soaking, dipping, and brushing. Univ. Ill. Agr. Exp. Sta. For Note 73.

Walters, C. S., and K. R. Peterson. 1958. Report on Project 301–A. Preservative treatment of fence posts by cold-soaking in pentachlorophenol—fuel–oil solutions. Univ. Ill. Agr. Exp. Sta. For. Note 77.

Walters, C. S., and K. R. Peterson. 1958. Report on Project 301–C. Preservative treatment of fence posts with toxic solutions. Univ. Ill. Agr. Exp. Sta. For. Note 78.

Other Than Continental United States

Anon. 1957. Modern techniques for the drying and conditioning of timber. (European productivity agency. Project 241). Organization for Eur. Coop., Suite 1223, 1346 Conn. Ave., N.W., Wash. 6, D. C.

Bavendamm, W., and H. Willeitner. 1957. Investigations on the practical application of the bored holes method for the impregnation of timber. Holz als Roh– u. Werkstoff 15 (10): 411–416.

Bavendamm, W., and W. Sczesny. 1957. Investigations on the practical application of the hot–cold bath process for the impregnation of lumber. Holz als Roh– u. Werkstoff 15 (10): 381–384.

Anon. 1957. Timber preservation in building: extracts of papers read at the annual convention of the British Wood Pres. Assco. Wood 22 (7): 287–290.

Ans, A. M. d', and B. Schulze. 1956. Electron-microscopic studies of impregnated woods. Holz Roh– u. Werkstoff 14 (7): 252–256.

Cockcroft, R. 1957. Movement of creosote in wood caused by drying of volatile solvents. Wood 22 (8): 331–337.

Etheridge, D. E. 1957. Method for the study of decay resistance in wood under controlled moisture conditions. Can. Jour. Bot. 35: 615–618.

Gewecke, H. 1957. Sap as solvent for impregnating salts used for the impregnation of poles by the open tank suction–, pressure suction-, and pile-suction-process. Holz als Roh– u. Werkstoff 15 (10): 416–417.

Göhre, K. 1958. Attempts on the impregnation of pine heartwood with taroil. Holz als Roh– u. Werkstoff 16 (1): 22–27.

Keino, K. 1957. On the ammonium salt of pentachlorophenol. Bul. 96. For. Exp. Sta., Meguro, Tokyo.

Körting, A. 1957. Further investigations on the determination of flour in wood used for the assessment of preservative treatments. Holz als Roh– u. Werkstoff 15 (10): 432–436.

Nowak, A. 1956. Investigations on the fungicidal effect of the components of different creosotes. Holz als Roh– u. Werkstoff 14 (7): 268–270.

Price, E. A. S. 1957. Correlating laboratory and field tests on the behavior of a wood preservative towards soft rot. Wood 22 (5): 193–196.

Perkitny, T. 1958. A new process for quick hot-gluing and simultaneous impregnation of laminates of all sizes. Holz als Roh– u. Werkstoff 16 (3): 97–101.

Reusse, W. 1957. The problem of wood-impregnation by radioactive preservatives. Holz als Roh– u. Werkstoff 15 (3): 125–128.

Ross, F. F., and M. J. Wood. 1957. Soft rot in cooling towers. Timb. Tr. Jour. 222 (4219): 69.

Scholles, W. 1957. The fungicidal and insecticidal properties of naphthenic acids and metal naphthenates as agents in wood preservatives. Holz als Roh– u. Werkstoff 15 (3): 128–137.

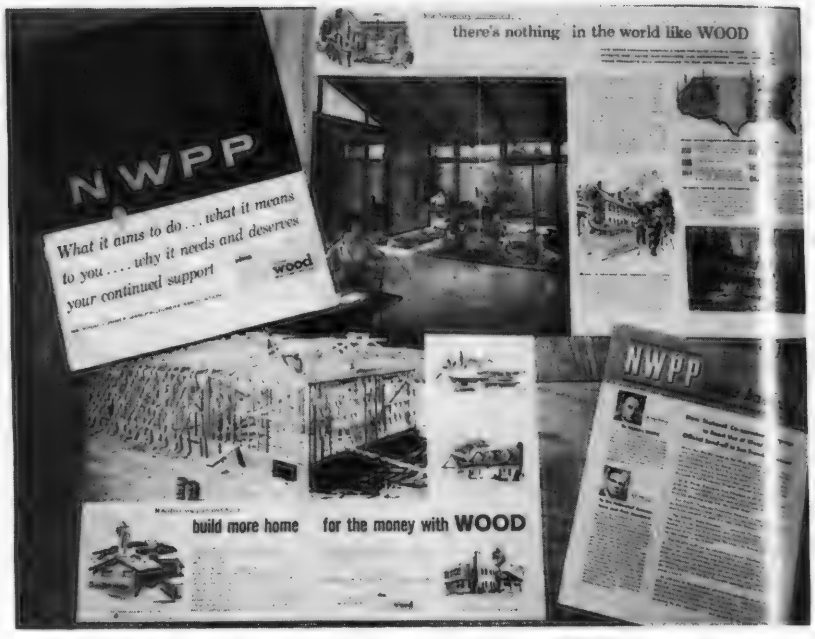
Yearsley, M. G. 1957. Final report on trials of copper naphthenate and mercuric naphthenates as wood preservatives. Emp. For. Rev. 36 (3): 387–391.

1958—YEAR OF DECISION FOR

Wood Merchandising

W. B. Lloyd
Chairman, FPRS Wood Merchandising Division

Wood's competitors are ever stronger and louder. NLMA's National Wood Promotion Program is the united effort of the lumber industry to stimulate increasing acceptance and use of wood.


there's nothing in the world like WOOD
NWPP
What it aims to do . . . what it means to you . . . why it needs and deserves your continued support
wood
NWPP
build more home for the money with WOOD

The NLMA program is a nation-wide three-pronged attack: large-space advertising, extensive follow-through promotional merchandising, and continuing consumer, trade, and professional publicity.

THERE HAVE BEEN MANY notable developments that have occurred throughout the long history of the lumber industry, but none surpassed that which happened in the year 1958. This 1958 milestone has been developing over 18 years. This development was the National Lumber Manufacturers Association's National Wood Promotion Program.

Competition to Lumber

The story of the inroads made upon wood by non-wood building materials is a familiar one. This competition began its most vigorous development since the year 1940. Evidence of this competition is illustrated by Table 1. It should be borne in mind that, while wood is used for purposes other than construction, as cited in Table 1, construction accounts for approximately 74% of lumber's use. Competition in other use areas, however, has been equally as severe.

Some of this competition has been the direct result of architectural changes such as the introduction of the concrete slab. Regardless of the reason, the use of wood has been eliminated in many cases. Table 1 illustrates some of the inroads made by architectural changes.

The increased use, of concrete slab construction, approximately 16%, caused the elimination of wood floor joists, bridging, sills, and subflooring. Garages, 1940-style decreased appreciably by 1956 and eliminated wood formerly used in their construction. The carport was not an able substitute, lumberwise, for the conventional garage. The predominance of one-story homes in 1956 decreased the quantity of wood formerly used in the multi-story residence. It also witnessed the elimination of many of the multi-story wood items, for example stairs.

Wood facing frame construction decreased by some 19% from 1940 until 1956, bringing the elimination of wood siding, shingles, and shakes. Wood sheathing declined by 18% while insulation board, much from non-wood materials, increased by a like amount. Wood shingles continued their downward trend from 1940 and lost 25% over that period. Asphalt shingles increased 19% during the same period. The use of built-up roofs increased and reflected the popularity of the flat or low-pitched roofs. Wood rafters usually employed in the gable roof were thereby eliminated.

Wood windows gave way over this same period. Aluminum window frames, relatively obscure in 1940, gained 29% of the market by 1956.

Wood, however, continued as the standard door material. Interior wood doors used in 1956 consisted of 91% of the flush type and 9% of the panel type.[1] The tremendous shift to the flush door was accompanied by less wood being used in their manufacture as compared to the panel door.

The above remarks have been confined primarily to the one-family house (Table 1). Recent data in the multi-family house show that the construction of duplex houses, apartment buildings, and other multi-family structures accounted for little more

The Author: William Lloyd is an Associate Professor in the Department of Forest Products, Michigan State University, East Lansing.

[1] U. S. Department of Labor, Bulletin 1231, August 1958.

Called "Livability Unlimited", this full-scale section of a house was built in a commercial photography studio as the setting for many of the photos to be used in the National Wood Promotion Program series of advertisements, literature, and publicity.

than a tenth of the privately owned non-farm one-family dwelling units started in the 1954–56 period. The shift from wood to aluminum window frames was even greater in multi-family than in single-family home construction. In apartment buildings, the proportion of windows with aluminum frames almost doubled between 1954–56. Only 60% of the living room floors of multi-family houses were of hardwood, 4% of softwood, and 7% of plywood. The remaining 29% were of non-wood materials.

Table 1.—CHARACTERISTICS OF NEW NON-FARM ONE-FAMILY HOUSES[1]

	1940	1950	1956
Basements			
Full or partial	69	39	43
No basement	31	61	55
On slab	(2)	4	16
Crawl space	31	57	39
Unknown	--	--	2
Number of Stories			
1 story	67	86	87
Split level			6
Other	33	14	6
Unknown	--	--	1
Garage Facilities			
Garage	80	41	50
Carport only	(2)	6	17
No garage or carport	20	53	31
Unknown	--	--	2
Exterior Wall Construction			
Masonry	11	11	16
Brick	10	6	12
Other masonry	1	5	4
Frame	89	89	83
Brick facing	20	12	26
Brick and wood facing			7
Wood facing	43	43	24
Asbestos shingle facing	4	21	9
Stucco	15	11	14
Other facing	7	2	3
Unknown	-	--	1
Sheathing (Frame Houses Only)			
Sheathed	69	80	83
Wood plank	49	40	31
Plywood	1	4	7
Insulation board	14	23	32
Gypsum board	5	12	9
Other	(2)	1	4
Unsheathed	31	20	17
Roofing			
Shingles	83	92	84
Asbestos			7
Asphalt	47	32	66
Wood	36	10	11
Built-up	5	6	11
Other	12	2	3
Unknown			2
Windows Above Basement (Predominant Frame Material)			
Wood	91	69	57
Steel	9	22	11
Aluminum		5	29
Unknown	--	4	3
Interior Wall Construction			
Plaster	90	50	44
On gypsum lath	56	49	40
On metal or wood lath	34	1	4
Dry wall	10	50	55
Gypsum board	--	48	48
Other		2	7
Unknown	--	--	1

[1] U. S. Department of Labor Bulletin No. 1231, August 1958.
less than 0.5%.

There were, never-the-less, some bright points in this period. Hardwood flooring was still used in 85% of all the 1956 houses. Wood kitchen cabinets saw a shift from wood to steel between 1940 and 1950, but by 1956, this trend was reversed and wood was used for approximately 90% of the kitchen cabinets for one-family houses.

Whether due to architectural changes or competition from other building materials, wood has lost considerable markets. This downward trend called for immediate action.

The Cause

Before action could be undertaken, the basic causes of the decline of lumber demand had to be ascertained. The following reasons for wood's decline were evolved:

1. Wood had been out-promoted by its competition.
2. The consumer had lost faith or contact with wood because of his lack of information about wood.
3. The success of discriminatory building codes, fire insurance ratings, and other miscellaneous legislation in restricting the use of wood.
4. The consumer rejection of wood because of the lack of a standardized quality product.

The many amplifications of the above reasons can be included within the scope of these four causes. It was such a basic analysis of wood's decline that gave rise to the NLMA National Wood Promoting Program.

Whose Problem?

The lumber industry consists of some 50 to 60,000 sawmills, 4 to 5,000 wholesalers or middlemen, and 30,000 retailers. In addition, there are thousands of woodworking establishments whose livlihoods depend on wood. When all of the organizations intimately associated with wood are listed, how does one decide where the basic responsibility for wood promotion lies? Much has been said regarding this area of responsibility. Some views are:

1. The manufacturer or sawmill should exhibit the greatest responsibility, because he succeeds or fails with the intensity of demand for his product. This same reasoning could also apply to the middleman because he, too, is dealing exclusively in wood. Should the middleman then be as responsible for wood's success as the manufacturer?
2. The retailer is prone to shrug off his responsibility because more and more he feels that wood is not the only important material of construction. The lumber retailer has become a "lumber and building materials" dealer with lumber sales, in many instances, representing less and less of his yearly business. Some retailers have indicated their willingness to sell that material, wood or non-wood, which sells with the least resistance and which retains the better markup.

Regardless of the responsibilities, the entire industry is in jeopardy if indecision reigns. It was this state of affairs that prompted the National Wood Promotion Program.

Training men in the use and promotion of wood . . . from the drawing board, through retailing, to on-the-job application.

The Decision to Act

In 1955, the National Lumber Manufacturers Association retained McKinsey and Co. to make an analysis of the lumber industry's future. The report showed that the future was bleak unless a vigorous and positive approach was made towards reversing the downward sales trend.

In 1956, NLMA's Board of Directors requested each of their 16 federated associations to appoint a committee to discuss a merchandising program. This culminated in the formation of a Special Merchandising Committee. The committee, in turn, named a sub-committee, which in the summer of 1957 retained Dr. James D. Scott of the University of Michigan to survey the marketing problem and offer his recommendations. The Scott report was accepted in November 1957, at which time NLMA's Board of Directors appropriated $25,000 to prepare the outline of a merchandising program. The following month, a Wood Promotion Planning Committee met in Tucson to approve the ground rules for this merchandising effort. The outline was developed by the advertising agency of Van Sant, Dugdale and Company,and on August 13, 1958, the plan was approved by the NLMA committee.

The Plan

Over a million dollars, $1,250,000 to be exact, was the amount appropriated by NLMA for the first year of the program. This national promotion effort will be financed by dues payments on lumber shipped by members of NLMA's now 17 federated associations. The program will also spearhead and tie together the various species and brand-name merchandising programs now being conducted by NLMA's regional associations and individual manufacturers. This will add another 5 million dollars to the originally appropriated 1.25 million dollars. The Program consists of:

1. Advertising in national consumer and trade publications.
2. Preparation of special booklets, product publicity, and other promotional material.
3. An expanded technical promotion field staff to work with architects, engineers, building code officials, contractors, and other bulk consumers of lumber and wood products.
4. A special effort to encourage increased promotional activities on the part of wood product and equipment industries closely allied to the lumber industry. The ultimate objective of this project would be to have all elements of all industries dependent upon the sale of lumber and wood products join in one unified national promotion effort.

The advertising agency responsible for the promotional plan believes that the program will pre-sell the customer on wood. The promotion has as one of its aims the creation of a more favorable climate for the promotion of particular brands and species. It further hopes to create an atmosphere of excitement about wood, and a broader knowledge of wood's many new uses for decoration as well as function.

A further objective of the program is to expand the Association's work in the fields of building codes and fire insurance rates, and to eliminate discrimination against lumber and wood products. The technical promotion field staff will endeavor to work with architects, engineers, school officials and others who influence the use of wood. A special effort will be made to encourage high school and college students to become more familiar with and thoroughly understand the technical aspects of lumber and wood products.

The promotional effort will make its first appearance in February, 1959 when LIFE magazine will run the opening advertisement of the program. This will consist of four pages in color. In succeeding months, a full page will be in each issue of LIFE. Likewise, in February, the NLMA will also launch its program in ARCHITECTURAL RECORD and ARCHITECTURAL FORUM. These magazines will contain a monthly advertisement for 12 successive months. Other magazines included in the program will be SCHOOL MANAGEMENT AND THE SCHOOL EXECUTIVE, AMERICAN BUILDER, PRACTICAL BUILDER, HOUSE AND HOME, and the JOURNAL OF HOMEBUILDING of the National Association of Home Builders.

The Future

The NLMA with its 17 federated associations has taken the initiative. The question of responsibility for the promotion of wood has been cast into the background. All who have a stake in this industry should support the program. The retailer, wholesaler, furniture manufacturer, or commission man, should all assist. Petty differences should be discarded, and lack of cooperation in this program should make lumber associations, industry members, and allied industries of questionable value to the lumber industry. There is little time to consider the adequacy of the program.

The results of this program are far reaching to all members of the INDUSTRY, for without markets, wood will die of its own inertia. Research without markets is futile, and 1958, the year of the inception of the NLMA National Wood Promotion Program, could be the start of a new era for wood.

1958 STATUS OF THE

Composition Board Industry

TECHNICAL COMMITTEE, FPRS WOOD COMPOSITION BOARD DIVISION

Production statistics and developments are summarized in this first Division Annual Review for insulation board, hardboard, and particle board.

INSULATION BOARD manufacturers and the raw materials they utilize.

SOME UNDERSTANDING OF THE SIZE of the present board manufacturing industry is of interest in properly appraising the importance of the field included within the scope of the Division. For comparison purposes, the following tabulation of production in the United States in 1948 and 1956 will afford a measure of the growth of the industry and the problems connected with that growth. The production figures are presented on the following bases: Insulation board on equivalent ½-inch basis and hardboard on equivalent ⅛-inch-thick basis as is the practice in those industries, and particle board on equivalent ⅜-inch-thick basis since that has been the practice for softwood plywood.

For practical purposes, production and use can be considered equal, since the small amounts of board imported and exported nearly balance and are small. The increase in manufacture of board products indicates that, in comparison with other forest products, the boards have either maintained or improved their position of relative importance.

Canadian members of the Society can report a parallel increase in manufacture of all three kinds of board. The export-import relation is quite different in that area in that the Canadian producers are major suppliers of the needs of the British Isles.

The status of each component of the composition board industry, what kinds of products are made, where they are used, how they fit into the over-all picture of forest products, and what their future possibilities are, all are of importance. The composition boards, along with other panel materials, are becoming increasingly important in many phases of construction, furniture manufacture, and other manufacture, from automobiles to railway cars. The following sections of this report detail pertinent information on the types of products included in each group.

Insulation Board

Insulation board as a material was developed commercially by the Minnesota and Ontario Paper Co. in 1914 as a means of utilizing sulfite screenings from paper manufacture, although pulpwood soon replaced screenings as raw material. The Celotex Corp. and Wood Conversion Co. soon followed with other plants. Since that time, the growth of the industry has been steady until at the present time there are 17 companies operating 23 plants in this country, including one in Hawaii. In Canada there are nine insulation board plants.

Insulation board is defined as being a board material, with a density between 10 and 26 pounds per cubic foot, felted from wood or other lignocellulosic fiber with the primary bond a natural one, although other materials may be added during manufacture to improve the bond or some other property. Most manufacture is in the 15 to 18 pound-per-cubic foot density range, and is in one of two basic types of board; a light-colored interior finish and a darker colored impregnated or coated water-resistant board.

Originally, most uses for insulation board were where thermal insulation was a major consideration, but many of the most important uses are developed around other properties such as structural strength or sound-reflectance suppression, particularly when the

PRODUCTION OF INSULATION BOARD, HARDBOARD, AND PARTICLE BOARD IN THOUSANDS OF SQUARE FEET[1]

Year	Insulation board	Hardboard	Particle board	Total
1948	2,386,955	957,080	-------	3,344,035
1956	2,972,593	1,498,193	570,000[2]	5,040,786
Percentage change	+25	+65	-------	+51

[1]Bureau of the Census, U. S. Dept. of Commerce. Wood Pulp, Paper and Board Facts for Industry.
[2]Estimated.

board surface is drilled or provided with other sound traps.

The two types of basic board products are fabricated into additional products. Nearly all insulation board is used in building construction, and the kind of product largely describes its use: Building board natural, lath for plaster base, roof insulation board, insulating roof deck slab, insulating fiberboard formboard, factory-finished interior board (including acoustical board), sheathing board, insulated siding base, shingle backer, and thin board. Factory-finished interior board, sheathing, and roof insulation board are the principal products volume-wise, and account for 30.4, 26.8, and 17.2 per cent of the total, respectively. Insulating roof deck slab, insulating fiberboard formboard, and shingle backer are new products with increasing volume of use.

Most of the established manufacturers of insulation board have recently expanded, have facilities under construction or are planning expansion that will increase productive capacity by an estimated 50 per cent over that of a few years ago. The main reasons for optimism in future use are the new products and the increased use of some of the established products such as acoustical board. Padding and blocking use of insulation board in packaging is one application that has every indication of increased future use. The present trend of the majority of producers toward manufacturing a board of higher than usual density (23–25 pounds per cubic foot density) foretells added use where higher strength and other engineering properties are required.

In the United States, about two-thirds of the fiber raw material for insulation board is wood. The remainder is bagasse, wastepaper, extracted licorice root, and flax shives. Thus about 1 million tons of the total estimated 1.5-million-ton-per-year raw material requirement comes from the forest. The principal sources of raw material and the number of plants may be divided as follows:

Principal raw material	No. of plants
Pulpwood	13
Bagasse	2
Wastepaper	2
Sawmill residues	4
Mixed raw material	2
	23

From the tabulation it is apparent that on the whole residues are not so important for raw material as is pulpwood. This is attributed to 2 things: 1) groundwood fiber is used to a greater extent than any other kind—this requires wood in the form of bolts rather than pulp chips, and 2) the locations of the mills are predominately not where large volumes of such raw material are available in single or centralized locations.

HARDBOARD AND HARD-PRESSED PARTICLE BOARD plants and their raw materials.

Further analysis of the predominate species used is warranted. Originally, practically all plants used long-fibered softwoods for insulation board, since they were avaliable in quantity and it was thought that only the springy long fibers of softwoods were suitable. Now, except for the plants on the west coast (3 of them using sawmill residues), all use hardwoods (particularly the medium- or low-density ones) in blends with softwoods, or exclusively.

Hardboard and Hard-Pressed Particle Board

Hardboard as we know it was developed around the Masonite system for preparing fiber by the explosion process and hot-pressing a wet mat of fiber to produce a hard, dense board with a natural ligneous bond. Except for the Masonite Corp. expanding several times at Laurel, Mississippi, only the U. S. Gypsum Co. at Greenville, Mississippi, established a plant for making hardboard in the period between 1928 and the end of World War II.

In 1948, the first small plant for manufacturing hardboard was constructed by the Chapman Manufacturing Co. at Corvallis, Ore. Since that time, numerous other smaller plants have been constructed. Many of these are in the Pacific Northwest where they can utilize as raw material the residues of a sawmill or plywood mill. However, some plants are located in other parts of the country. At present there are 15 companies operating or building 16 plants for the manufacture of hardboard. About one-half of the total production is still in the large plant of the Masonite Corp. at Laurel. Canada has three plants.

Hardboard is manufactured by converting wood to coarse fiber, conveying the fiber by water or air, and felting it into a mat. The mat is either dried and pressed between the platens of a hot press or is dried and then hot pressed. When conditions of moisture, heat, and pressure are carefully controlled and the resulting board has a density of at least 50 pounds per cubic foot, a natural ligneous bond characteristic of hardboard results. When wet or damp mats are hot pressed, it is necessary to use a screen next to one caul of the hot press to allow moisture to escape as steam. The resulting board has the impression of the screen on one surface and is known as screen-back board.

When previously dried wet-felted mats or dry air-felted mats are hot pressed, it is possible to have a board with both faces smooth. These are called S–2–S hardboards. Hardboards are manufactured in a density range from 50 to 80 pounds per cubic foot. The air-felting processes for making hardboard have been described as being "dry" or "semi-dry," in contrast to the term air-felting used in this Division report.

In addition to the conventional hardboards (those with a primary natural bond), there is a group of hardboard-like materials manufactured by bonding fibers or particles that approach fibers together with synthetic resin adhesives. These are more properly called "hard-pressed particle boards," although they are often sold as hardboard and are used for some of the same applications. There are five plants manufacturing such products.

Hardboard is manufactured in three basic products; a utility board with a density of about 55 pounds per cubic

RAW MATERIAL
SAWMILL OR PLYWOOD MILL RESIDUE
MILLWORK OR FURNITURE MANUFACTURING RESIDUE
ROUNDWOOD
MIXED RAW MATERIAL OR EXACT RAW MATERIAL NOT KNOWN

RESIN-BONDED WOOD PARTICLE BOARD plants and their raw materials.

foot, a standard hardboard with a density of about 62 pounds per cubic foot, and a tempered or oil-treated grade with a density about 5 per cent greater than the standard board because of the blend of oxidizing resin oils that are impregnated into the board and stabilized by baking.

About one-half of the hardboard is of the tempered grade and the remainder is divided between the utility and standard grades. About one-half is sold through retail lumber yards and the other one-half is sold industrially. The board sold through retail yards finds its way mainly into construction such as housing. The board sold industrially goes into some manufactured product as furniture, automobiles, railroad car linings, or a component for a house, like a door, cabinet, or storage unit.

Hardboard has been called "the versatile panel material of 1,000 uses." Special boards, such as those with high impact resistance and boards planed to close thickness tolerances, are available. A whole line of decorative surfaced hardboards is manufactured by embossing to simulate leather, etched wood, ceramic tile, and basket weaves, or by grooving and punching to produce striated, grooved, and perforated surfaces. Highly reflective enameled and lacquered boards as well as those with a printed grain to simulate fine cabinet woods are produced.

Hardboard is being used in increasing amounts as exterior siding, underlayment, interior wall surfacing, flush door facings, concrete form lining, and other applications in house construction. It has captured important industrial uses, such as radio and television cabinets and backs; automobile door panels and sun visors; and dust dividers, drawer bottoms, and backs for furniture case goods.

In the United States, wood is used exclusively as the source for fiber for hardboard and hard-pressed particle board. The following summary by types of raw material and number of mills shows that, as far as number of plants is concerned, residues from sawmill or plywood mills are a more important source of raw materials than for insulation board:

Principal raw material	No. of plants
Sawmill or plywood mill residues	8
Pulpwood	11
Mixed raw material	2
	21

Again, nearly all plants that use residues are located in the far West. The above figures are misleading because, of the total hardboard production, about one-half is concentrated in one plant. This plant is forced to rely primarily on pulpwood though it is increasing its chip purchase program. Even more important from the utilization standpoint is the species of wood used in the plants that rely on pulpwood for raw material. Eight of them use hardwoods, either exclusively or principally, for their raw material.

Particle Board

Although patents existed before 1900 for gluing together particles of wood into board, the particle board industry was made practical by the development of economical thermosetting resins. The industry started in Germany and Switzerland in the early 1940's and in the United States about 1947. Plants in general have been smaller than for insulation board and hardboard, although there are some large ones. A substantial number are captive plants, in that all or nearly all of the production is used in further manufacture in the same plant where it is produced. Partly because of the amount of capital required and partly because of the use of residues from other forest products manufacture, particle board plants have sprung up all over the country until there are 63 of them either completed or under construction. This is in addition to the five plants that manufacture hard-pressed particle board discussed with hardboard. Canada has only 3 plants.

In the fibrous-felted boards the bond is a natural one, but in the case of particle board the bond is produced by the thermosetting resin. More properly, they could be called "resin-bonded wood particle boards." The particles range in size and shape from large flat flakes through chips, slivers, strands, and granules, to fines that approach flour in size. They are produced by hammermilling with special cutting machines for the special engineered particles. Two resins are usually used; urea-formaldehyde resin for about 80 per cent of the volume, and phenol-formaldehyde resin for the remainder.

The blend of resin and wood particles is pressed and the resin is cured with heat while under the pressure. Two types of presses are used. About six-sevenths of the total particle board is pressed between the flat platens of a conventional hot press. Board so made is said to be flat-platen pressed. The remaining one-seventh is made by forcing the resin-particle blend through a long, heated die. Those boards are classified as extruded.

Most particle board is manufactured in the medium-density range, 25 to 50 pounds per cubic foot, although some boards for special uses are manufactured at a density greater than 50 pounds. Theoretically, insulating-type particle boards can be manufactured, but to date in this country they have not proved practical because, to be economical of resin, a board must be compressed during manufacture to a density in excess of that for the species used for the particles. Flat-platen boards are manufactured from the same type of particle throughout or may have a core of one type of particle and facing or facings of another type to provide additional strength, or a smoother or more decorative surface than would be obtained otherwise. Extruded boards are manufactured from the same type of particle throughout, usually hammermilled slivers. For thick sections, boards may be extruded with tubular (hollow cores) openings parallel to the extruded direction.

Particle boards were originally used almost exclusively as an alternate to

lumber core in veneered construction. With the improvement of the quality of the flat-platen boards, they began to be used as panel material where the surface, strength, and other properties were satisfactory for the use without added facings. Those with decorative facings were sometimes preferred for special architectural treatments. Uses developed to date where the board is used without added facings of veneer or plastic include, besides decorative interior paneling, sliding doors for cabinets and wardrobes, floor underlayment, finished floor tile, and furniture paneling. In other uses, the stiffness, strength, and dimensional stability of some particle boards are proving to be satisfactory for furniture applications where no crossbands are required, as is usual in 5-ply construction.

In the United States, wood is used exclusively for the lignocellulosic component for particle board. In other areas of the world, flax shives and bagasse are used also. The wood raw material may be green or dry planer shavings, sawdust, waste veneer, green or dry sawmill or manufacturing solid-wood waste, or roundwood. It is apparent from the following tabulation of the main sources of raw material for particle board plants that residues from other forest products manufacture are of greater importance than for insulation board and hardboard. One additional category has been included because of the large percentage of plants that depend on manufacturing byproducts from millwork or furniture manufacture for raw material.

Principal raw material	No. of plants
Sawmill or plywood mill residues	21
Furniture or millwork manufacturing residues	22
Pulpwood	9
Mixed or unknown raw material	11
	63

Three things appear to be significant in terms of raw material considerations. First, the two major raw material sources are residues. Those that utilize sawmill and plywood mill residues are in the far western states, and those that use millwork and furniture manufacturing residues are mainly in the Southeast, with a few in the Central and Northeastern states. Second, that while originally all plants were predicated on the utilization of what otherwise could be classed as waste, nevertheless pulpwood is becoming increasingly important with nine plants already using it as a primary raw material. This is undoubtedly influenced by the trend to the manufacture of higher quality boards from engineered particles such as flakes. In fact, nine of the last eleven plants completed or under construction will be based on flake-type particles for most or all of their product.

The Year 1958 and the Future in Board Manufacture

The year 1958 was one of recovery for the board manufacturing business. The business recession, particularly with its effect on construction activity, hurt all board manufacturing, particularly during the last quarter of 1957. This, coupled with the faster development of manufacturing facliities for particle board than the development of the uses for the productive capacity, made early 1958 a pessimistic time on the part of many people connected with particle board.

In an industry less than 10 years old, the effect was the closing of some plants and the holding back of construction of others. The need for standards became acute, but because of the manifold number of products produced and the desire of producers to have all products, both flat-platen and extruded, in one specification, and the lack of fundamental information on the properties needed for different uses, the problem so far has proved unsurmountable.

Even the matter of nomenclature and definitions has proved to be a disadvantage in the past. While it has not been the objective of FPRS to promulgate standards, nevertheless it is interested in promoting such things as would aid the industry. During the past year, American Society for Testing Materials accepted D1554–58T, Standard Definitions and Terms for Wood-base Fiber and Particle Panel Materials, and it is significant that several members of the Division of Wood Composition Board were instrumental in the development of that standard. It will remain tentative for two years and then either be revised and continued as tentative or advanced to standard.

In particle-board manufacture, sales, and use, several things became apparent. The organization of sales proved most important. Those companies with established sales organizations for allied products maintained and extended their sales while those smaller plants without them found that more than local sales efforts were usually required. The minimum economic size of plant was influenced by the cost of maintaining an adequate sales force.

The trend was definitely established that higher quality, better strength, more dimensionally stable particle boards held the greatest future promise. It had been demonstrated several years ago in the laboratory that particle board manufactured from well-cut, engineered particles would approach plywood in most important properties and exceed it in others. The manufacturing advances during the year and the trend to flake-type board manufacture in new plants being established supported this trend.

Considerable attention was directed to the use of resins and binders more durable than urea-formaldehyde so particle board could assume a place among exterior materials. Several manufacturers started using phenolic resin binder for part of their production where high temperature or moisture resistance was necessary. The resin manufacturers themselves are devoting increased percentages of their research effort toward the development of more durable, economical resins for these purposes.

If one word were to describe the insulation and hardboard industries it would be *diversification*. The continuation of the practice of developing new, more, and better products indicates future expanded use of these products. Also, all producers were doing more remanufacturing. This includes better cut-to-size service to the customer, special boards for special purposes, and factory primed and finished boards.

Most noteworthy among the new products were the higher density insulation boards, 23 to 25 as compared to 17 to 18 pounds per cubic foot density, for many uses where higher strength is desired. One manufacturer of insulation board is enjoying success with a board of 35-pound-per-cubic-foot density marketed primarily for use as house siding.

The more optimistic feel that insulation board, hardboard, and particle board will maintain and enhance their positions with other forest products and construction materials for the following reasons:

1. Cost of applying and using materials is becoming increasingly important as labor costs rise faster than material costs.
2. Availability in large sheets means less waste when used, and, because nominal dimensions and actual are the same, 100 square feet of board means 100 square feet of coverage.
3. The board materials have maintained and promise to maintain their relative cost as compared with other forest products.
4. Contemporary designs require the properties of greater uniformity present in insulation board, hardboard, and particle board.
5. Increase in prefabrication and dry-wall construction will require more of such materials as board and plywood.

IMPROVEMENTS BY REGIONS TYPIFY

Lumber Manufacturing in 1958

M. H. MATER
Chairman, FPRS Lumber Manufacturing Division

1958 was a year of improvement for lumber manufacturers. Changes were more numerous in the East. Centralization was the theme in the South. Mechanization was steady.

Fig. 1.—Mechanized log segregation has won wide interest. This system in a South Eastern mill is typical.

DURING THE YEARS IN WHICH this Annual Review has been prepared, the ups and downs of lumber manufacturing appear to have followed a cyclical pattern. The year 1954, for instance, started poorly and ended as a good year. During 1955, the industry enjoyed a very high level of prosperity, but '56 started as a boom and ended as a bust, followed by a poor year in 1957.

"Improvement" was the key word in 1958 reports. The year started slowly but ended on a note of optimism, and if the marked cyclic character of the industry runs true to form, 1959 should be another banner year. Many mills have reopened in 1958, and new mills have been started.

Eastern Mills Changing Rapidly

The greatest excitement in sawmilling activity appears to be in the eastern part of the United States and Canada, not confined to the traditional "East of the Mississippi area" but in the eastern half of the country. While western reporters found few changes, most eastern reporters of the Lumber Manufacturing Division mentioned many changes.

The Georgia, Alabama, and Mississippi region has seen a change from the concentration yard with its combination of 5 to 10 peckerwood mills in the woods to a centralized larger mill at one location. This change can be largely attributed to the waste utilization program, which necessities putting in expensive debarkers and chippers in order to stay competitive.

A typical illustration of the change is the Langdale Co., at Valdosta, Georgia. Five years ago this was a concentration yard that operated 10 peckerwood mills in the woods. Each peckerwood mill was sawing under contract, by the thousand, and delivering the rough sawn lumber to the concentration yard. This company has just completed a modern central sawmill and elimianted all the other peckerwood mills that were previously used. That this type of change is typical is apparent from the fact that, of 97 mills covered in the report, 16.5 per cent were new mills.

The Eastern Central region is looking with interest to Union Carbide's new automated sawmill, which will be in operation next year. This is Union Carbide's first venture into sawmilling.

A changing trend in mill sizes is also evident in the North-eastern States. Both large and small mills in the area from Maine to West Virginia are dropping out, while mills that cut 10 to 30 M per day are increasing.

Reports from the West indicate no apparent change in trend in mill sizes. Giants such as the Diamond–Gardner Plant in Red Bluff, California, were built as were medium-sized mills. Considerable interest is shown in highly automated plywood core mills. The completely integrated mill, which includes a sawmill, remanufacturing plant, and residue utilization plant, is coming in for its share of attention. A medium-sized mill in Western Canada is building a complete integrated plant that should be in operation by late spring.

Mechanization Pace Steady; Spurts in Some Regions

The mechanization of sawmills, begun a number of years ago, continues. In some regions the trend has spurted,

The Author: Milton Mater holds a BS in mechanical engineering. He is head of Mater Engineering, sawmill consultants, and Mater Machine Works, sawmill machinery manufacturers.

Fig. 2.—Typical of changes in sawmilling is the increasing importance of the sawyer, who now automatically handles a variety of mill operations.

Fig. 3.—The competitive necessity of putting in debarkers and chippers to make profit from residues has changed the character of mills in some regions.

in others it has accelerated, and in others merely maintained its steady pace. In the Northeastern States there are about 30 completely automatic carriages, and many more are being mechanized. Automatic edgers and trimmers are finding more application.

The Lake States and East Central States, after a slow start in 1957, have taken a mechanization spurt and mills are rapidly converting from manual to automatic operations. Riderless carriages, new conveyor system and lumber loaders are representative of the type of mechanization.

In a tabulation of 97 Southeastern mills, 18 per cent installed lift trucks, log loaders, and so forth; 13 per cent installed new gangs.

The Central States area has concentrated on straddle and fork-lift trucks for handling to offset the high cost of labor.

The California Redwood region noted a trend toward riderless carriages, sliver tooth saws, and in some cases gang saws.

Remanufacturing, Planing Mills Modernized

A report from the Puget Sound area in Seattle, Washington, which may be considered typical of Douglas-fir mills on the West Coast, states that line-bar resaws are becoming increasingly popular and seem to be a major objective in the mill modernization programs of the larger mills in the area.

Modernization of planing mills continues through out most old-line sawmills in the area, with probably more money invested in the remanufacturing plant during the past year than in other phases of sawmilling. Tilting unloaders, modern conveyors, automatic end trimmers, end stamping devices, grade stamping units, and modern retrimmer are typical installations.

The young Pacific Northwest Hardwood industry is looking toward more remanufacturing to develop the industry.

Barking, Chipping Lead in Residue Utilization

The interest of previous years in barking and chipping has been translated into brisk action. In the Northeast there are about 100 log barkers now installed, mostly in the northern part of the region. Three new community chipping plants have been installed. Of 97 Southeastern installations, 52 per cent installed debarkers and chippers in the past 18 months. Interest in debarkers is still in the talking stage in the Central States.

One Bellingham-type barker is being installed in a large redwood mill, and various types of barkers are being considered in other mills. A poor chip market is dampening enthusiasm in this area.

In the Douglas-fir region, debarkers are continuing to be of speculative interest to medium-size mills within economic hauling radius of pulp or other fiber markets. Pulp mills have placed suppliers on a quota system until pulp demand rises, with the result that most debarker plans are for a few years into the future.

Research Projects Active

Research in the lumber industry is picking up activity. Georgia–Pacific in Oregon organized a research division during the past year, and hired several top-flight men. The University of Oregon in Eugene organized a Forest Products Management Center to do research to help management in the industry solve problems of cost analysis, linear programming, and office procedures relating to lumber manufacturing.

The University of Missouri received a $27,000 grant for research into wood-using industries. The California Forest Products Laboratory is working on solvent seasoning, and has been giving considerable attention to the treatment of redwood siding and pattern stock with toxic water-repellent materials.

A new wood products laboratory at Yale will be ready for occupancy in February, and another laboratory is scheduled for the University of Massachusetts.

It is of research interest to note the fields of concern of members of the Lumber Manufacturing Division. In a postcard survey that asked members on which standing sub-committee they wished to serve, 24 per cent were interested in quality control, grading and standardization; 22 per cent in log handling; 17 per cent in log breakdown in the sawmill; and 11 per cent in lumber handling.

100 Research Projects

This review was prepared from written reports from area and regional Lumber Manufacturing Division Chairmen throughout the United States and Canada. This committee has had an active year, highlighted by the compilation of "100 Sawmilling Research Projects" by Norman C. Lee and the Chairman, which it is anticipated will stimulate needed research in lumber manufacturing.

A PROGRESS REPORT...

Glues and Gluing, 1958

R. F. BLOMQUIST[1]
Chairman, FPRS Glues and Gluing Division

Importance of wood adhesives was emphasized by formation of Subcommittee X, Wood Adhesives by ASTM Committee D-14. Developments in glues and gluing processes have not been revolutionary, but fundamental and applied studies have made significant progress.

Fig. 1.—Battery of 4 air-hose laminating presses with short in-feed conveyors for cold-pressing doors or table tops with polyvinyl resin emulsion glues in short press cycles. Courtesy: Black Bros., Inc.

THE "AGE OF ADHESIVES" is certainly upon us. The interest in adhesives and adhesive bonding processes for various types of materials and constructions is increasing greatly year by year. A new magazine was launched to cover developments in this field; the first issue of ADHESIVES AGE[2], appeared in October, 1958.

The importance of adhesives in the wood industry was recognized by the American Society for Testing Materials Committee D–14, which recently organized Subcommittee X on Wood Adhesives. This committee held its first actual meeting in April 1958 at the U. S. Forest Products Laboratory, and committee organization is now well underway. During the fall of 1958, a West Coast group of Subcommittee X was organized in Seattle. This group will work in cooperation with the East Coast or main group of Subcommittee X to develop test methods and specifications for wood adhesives. R. F. Blomquist is chairman of Subcommittee X and J. R. Ash is chairman of the West Coast group.

During 1958, the fifth Gordon Research Conferences on Adhesion was held in New Hampton, N. H. This is a recognition of the importance of adhesives and adhesion problems in all fields. A number of individuals with specific interest in wood adhesives attended this and earlier conferences. Dr. Alan Marra of the University of Michigan is now organizing the sixth Conference on Adhesion for August 1959 in his capacity as Chairman of the Conference. It is interesting to note that this conference, which gives attention primarily to the underlying principles of adhesion, has now recognized more clearly the importance of the cohesive forces in an adhesive bond as well as the actual adhesion to the adherends themselves.

General fundamental studies of adhesion are of course of direct interest to adhesion for wood. Marian, Stumbo, and Maxey reported on "The Surface Texture of Wood as Related to Glue Joint Strength." (1)[3] As has been pointed out earlier, an adhesive bond in wood to wood is essentially a chain of five individual links. The breaking of any one of these links results in practical failure in the joint. These links include, in the order named, the cohesive strength of one wood adherend, the adhesive bond between the adhesive film and the wood, and cohesive strength of the adhesive film itself, the adhesive bond of the other film surface to the wood, and the cohesive strength of the other wood adherend. Much of the basic research in the problems of bonding wood are concerned with the investigations of the factors that involve the quality of the second, third, and fourth link. A common criterion of satisfactory bond, of course, is that these second, third, and fourth links will exceed the strength of links one and five, thus resulting in complete wood failure in the well-made joints.

As in earlier annual reviews, there have been no revolutionary developments during the past year. The developments in adhesives, adhesive bonding processes, and new bonded wood products continue through an evolutionary process. Some changes probably would go almost unnoted. Whenever possible, significant new items will receive special notice in this review. A certain amount of mate-

[1] Acknowledgement is made to a rather large number of members of the Glues and Gluing Division who have contributed to the preparation of this report. Some of the major contributors are: T. McKenna, Monsanto Chemical Co.; A. A. Marra, U. of Michigan; J. L. Ziegler, A. D. Little; J. E. Marian, California Forest Products Lab; B. S. Bryant, U. of Washington; C. C. Booth, Borden Co.; R. W. Peterson, Ottawa Laboratory, FPL of Canada; R. M. Williams, American-Marietta Co.; L. F. Bornstein; Synvar Corp.; and A. H. Rauch, U. S. Plywood Corp.

[2] Published by Palmerton Publishing Co., Inc. N. Y., N. Y.

The Author: Richard Blomquist holds a BA from Coe College, and MS and PhD degrees from the University of Iowa. He is head of the Glues and Gluing Section, Timber Processing Division, U. S. Forest Products Lab.

[3] Numbers in parentheses indicate references listed in the bibliography.

rial repeated from earlier reviews is included in order to indicate more clearly the status of glues and gluing at the present time.

Interest continues in the upgrading of wood and wood products by the use of glues and gluing through the combining of different grades of wood, of different species, and of wood with other materials to make new products with superior properties that are better able to compete with non-wood materials.

Adhesives

It is difficult to get accurate and specific figures on the actual quantity of adhesives used in the woodworking industry in the United States at the present time. Some figures reported by the U. S. Tariff Commission illustrate the relative amounts of the different synthetic resin glues produced.

RECENT PRODUCTION OF SYNTHETIC RESIN ADHESIVES[1]

	1956 (1,000 lbs.)	1957 (1,000 lbs.)
Phenolic and other tar acid resins		
Bonding and adhesive resins for plywood	51,213	46,887
For all other bonding and adhesive uses	48,948	51,169
Urea and melamine resins		
Bonding and adhesive resins for plywood	107,617	98,115
All other bonding and adhesive uses, including laminating	30,170	1,054
Vinyl resins for adhesives (Other than vinyl chlorides and copolymers)	41,729	41,965

[1]Quoted in Modern Plastics Encyclopedia for 1959, p. 591. Original Source, U. S. Tariff Commission.

Data are not available to indicate the corresponding amounts of the non-resin adhesives used on a comparable basis. The amounts of adhesives used in the plywood industry in Canada during two recent years are:

ADHESIVES CONSUMPTION IN THE PLYWOOD INDUSTRY IN CANADA[1]

Adhesive type	1955 (lbs.)	1956 (lbs.)
Phenolic	37,607,190	53,818,965
Urea	11,861,832	9,371,845
Casein	1,083,872	2,261,929
Vegetable	5,095,593	4,324,419

[1]Source, Dominion Bureau of Statistics.

One really new type of adhesive, Eastman No. 910, was introduced in the United States during the past year, without any particular adherend in mind. This cyanoacrylate adhesive has been used on an experimental basis for bonding a number of materials, although no actual experience on the bonding of wood is available (2). Through wide publicity and because it is apparently 100 per cent reactive and fast setting at room temperature by the action of slight amounts of moisture present in the air and in the adherends, this particular type of adhesive has captured the imagination of a large number of people.

The older non-resin glues continue to find an important place in the woodworking field. Animal glue is still widely used, particularly in furniture assembly and similar applications. There appears to be a greater interest in the use of liquid forms of animal glue. Starch or vegetable glues are used to a relatively small extent, primarily in the hardwood plywood industry yet, but they have lost much of their market to the urea resins in recent years for such applications. Soybean glues, once the work horse for bonding interior-type Douglas-fir plywood, continue to be used in a large volume although the amount appears to be decreasing in proportion to other glues primarily because of the introduction of hot-press protein glues and extended phenolic resin combinations with blood, Douglas-fir bark, furafil and other extenders for reducing glue line cost.

Casein glue is still the major glue used in the bonding of structural laminated timbers, where its use is limited to those for interior service. Dry soluble whole blood has been used in formulating hot-press glues alone or in combination with soybean and other proteins for a number of years. Recently a cold-press straight blood glue has appeared as a bonding agent for interior-type Douglas-fir plywood.

Among the synthetic adhesives, urea resin and the phenolic resins continue to be used in large quantities. Urea resin is the work horse of the furniture and hardwood plywood industry. Although there have been no really basically new developments in urea resins in recent years, there have been a number of important new formulations developed for use under specific plant conditions and for specific types of wood products. These glues are used not only for cold-press and hot-press production of plywood but are also used in the splicing of veneers, the edge gluing of lumber core stock, and the assembly of flush doors for interior service.

Rose has reported on some interesting factors in developing specific urea resins for wood gluing (3). A new high-solids liquid urea resin with a separate lubricated catalyst is reported to be replacing conventional powdered tapeless-splicer adhesives for the splicing of veneer in many plants, particularly those that purchase liquid urea resin in bulk for other gluing applications. The formulation is said to be more economical for tapeless splicing than is the powdered adhesive.

Melamine resins are used primarily as fortifying agents for urea resins. The amount of melamine resin added to the urea resin is controlled by the permanence expected of the glue joint in service. This type of combination of resins has been used quite extensively in the last year or two for edge and end gluing of lumber into panel form as well as for producing much of the Type I hardwood plywood made for exterior and other severe service.

Phenolic resins continue to find their biggest market in the West Coast softwood plywood production, where they have long been used as the bonding agent for exterior-type plywood. More recently their use has been increasing in interior-type glue lines. In this application, the glue line cost is reduced by incorporation of blood, furafil, bark, and other extenders. There continues to be speculation on the shift in the softwood plywood industry to the exclusive use of phenolic resin glues, and either manufacture exterior-type plywood only or to use the extended phenolic resin glues in the manufacture of interior-type plywood (4). One chemical manufacturer has plans now for building a new 30 million lb per year capacity phenol plant in the Pacific Northwest to provide the raw material for making phenolic resins, assuming that the plywood industry will expand along these lines.

There haven't been any important new changes in the phenolic resin plywood-bonding glues in this country during the last few years except to produce glues that are more economical and work better on the lower quality veneers now commonly encountered in the industry. American phenolic resin glues still are cured at 260° F. or higher. The British report their phenolic resin plywood glues are commonly cured at 110 to 115° C. (230–239° F.). It should be noted that moisture content of their finished plywood is somewhat higher than that produced in this country, because of a higher equilibrium moisture content of wood in use in the British Isles. The gluing of veneers with high moisture content requires low curing temperatures in order to reduce the problems with blisters.

Film glue is now reported to be produced on the West Coast for the plywood industry. This is a phenolic type glue. Its use is reported to result in less compression in panels. Other advantages claimed are elimination of mixing and spreading equipment and reduction in the variation in plywood panel thickness. Better-cut veneer is probably required for its successful use. The introduction of this film ad-

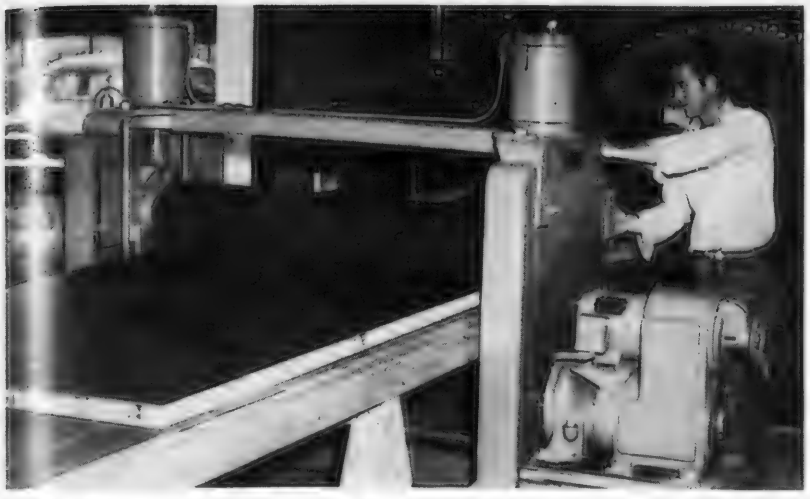


Fig. 2.—Rotary press for gluing skins on doors in a continuous process. Door is approaching. Infra-red drying unit is in background. Courtesy: Black Bros., Inc.

hesive is said to have stimulated thinking in the direction of automatic layup in plywood production.

Resorcinol resins have been pretty well standardized over the past several years. The newest developments in this field have been the copolymerization of resorcinol and phenol with formaldehyde for the production of glues of somewhat lower price than the straight resorcinol resins used for durable glued products such as exterior laminates.

The polyvinyl resin emulsion glues have been rather well standardized also in the past 10 years, with polyvinyl acetate emulsions being the principal type of interest in wood gluing. These glues have been adapted for a short clamping process, commonly with 20- to 30-minute clamp periods in such operations as gluing plastic laminates to plywood cores for table and desk tops, and for cold-press bonding of flush doors in a short press cycle (Fig. 1). Originally these glues were plasticized with separate plasticizers, but in recent years more attention has been given to the possible uses of copolymers in which other monomers are polymerized with the vinyl acetate to provide an internally plasticized resin. The most recent development in these emulsion glues has been their combination with phenol and urea resin glues.

Epoxy resin glues, originally based on condensations of epichlorohydrin and bisphenol, were first used several years ago as adhesives for metal-bonding in the aircraft industry. Exploratory studies on gluing wood with these adhesives indicate that some will give joints with adequate dry original joint strength. Their durability characteristics have not been adequately investigated. At the present time there is interest in the use of these adhesives in woodworking particularly because of the fact they are potentially 100 per cent reactive, and will cure without the evolution of volatile solvents and byproducts at normal room temperatures. They also have an ability to adhere well to a variety of other surfaces including many plastics and metals and even glass. They are of only limited interest for the conventional wood gluing operations at the present time because of their high cost (5).

A type of adhesive receiving a considerable amount of study in the wood industry in the past two years is the rubber-base contact-type cement. These adhesives are commonly based on neoprene rubber and are solutions in volatile organic solvents. They were originally offered for bonding plastic laminates to wood and other wood-base materials for counter tops and furniture tops. They are commonly applied to both of the mating surfaces and allowed to air dry to a tack-free condition, then the faces are brought together and pressed under relatively low pressure for only a very short time. For industrial bonding on a continuous basis, the cement-coated surfaces are dried in infrared dryers, assembled immediately while warm, and run through a rubber pinch roll (Fig. 2). These adhesives are thus based on the principle of producing a high initial cohesive strength in the adhesive film as well as relatively good adhesion due to physical effects rather than on any sort of curing phenomenon. Experience with presently available contact cements indicates that they produce joints of relatively low strength compared to conventional wood adhesives, and that their adequacy for many applications in woodworking are yet to be examined and evaluated.

Contact cements are being used in the United States and Canada on a limited basis in the gluing of interior-type flush doors and certain types of furniture panels of frame construction as well as for the bonding of counter tops and table tops and on-the-job installation of plywood paneling to wall-framing members.

One of the new developments in the past year has been in introduction of water-base rubber cements in emulsion forms. Part of the setting action of these new cements is due to the breaking of the emulsion, somewhat similar to that of the polyvinyl acetate emulsions. Water-emulsion contact cements have advantages over the conventional solvent-type in being non-inflammable, less toxic, and potentially less expensive, but like the solvent-type their potentials in the woodworking industry have not yet been adequately studied.

Neoprene contact-type cements have also become important in house construction for bonding thin veneer flooring to concrete slabs. During the past year, one manufacturer has begun to produce this type of press-dried veneer flooring and another manufacturer is reported to be soon coming into the field. This type of flooring is intended to compete with rubber, asphalt, and plastic tile floors laid directly over concrete slabs in one-story houses. Since such thin veneer strips or squares do not have a tongue and groove or other mechanical edge features that aid in holding down the adjacent tiles, the adhesive must be stronger than conventional mastic cements in order to hold independently each wood piece tightly to the subfloor. The rubber-base contact cements appear to be the most adequate of the currently available types for this kind of bonding.

The trend for improving adhesives by combinations of different types of resins or of resin and non-resin continues. The development of high-strength metal-bonding adhesives during the past few years has suggested the advantages to be gained by combining two or more base resins to acquire the desired properties from each. Of current interest are the combinations of urea resin and polyvinyl acetate that give somewhat greater water resistance and permanence and the freedom from creep characteristic of the polyvinyl acetate, and retain the quick-setting properties of the latter glues.

Another combination is that of certain protein-type adhesives with either synthetic or natural rubber latex. This is an outgrowth of the older casein-latex cements used some years ago for bonding wood to metal. These protein-latex adhesives are now used to some extent for bonding of flush doors

and similar applications in a short clamping period in order to produce somewhat higher moisture resistance than is characteristic of the polyvinyl acetate emulsion glues also used for this purpose.

Another combination is that of melamine and urea resin for producing a glue with somewhat greater durability than the straight urea-resin glue. A new type reported during the past year is the blood-modified casein adhesive designed primarily for hollow-core flush door applications. It offers the advantages of quick clamping and water-resistant bonds. Because of its rather high water-glue ratio, it is not recommended for solid-core doors or for laminating operations. It may be expected that this development of new resin combinations for adhesives will continue.

Extenders for Glues

Interest in developing reactive-type extenders based on other forest products as well as agricultural byproducts continues. Extenders, of course, are used to reduce the cost of the more expensive synthetic resins.

The mixing procedures for the furafil-extended phenolic resin glues in the West Coast plywood industry have been further simplified. The new procedures call for higher cost resins so that mixing in the plywood plant is simply a matter of adding furafil and water without heating. This procedure is reported to be used extensively in the British Columbia plywood industry at the present time.

A number of investigators have been working on the development of adhesives or extenders for resin adhesives from the tannins in bark. Evidently there are great differences in bark constitutents from various sources, which influence their usefulness as glue additives (6, 16).

Cashew nutshell oil has been studied both for room temperature and hot-setting adhesives for plywood and particle board (13, 14). Seed protein adhesives have been investigated in India (15), and the suitability of peanut meal residues for plywood glues has also been studied (16). The solubility of albumins as criterion for plywood glue manufacture has been studied (17). Glue joint strengths of blood proteins at the isolectric point was investigated by Japanese researchers (18). Crude phenols (mixtures of phenol, cresol, tricresol, and xylenol) condensed with formaldehyde have been tried as plywood glues (19). The development of wood glues based on combinations of phenol-aldehyde and sodium silicate are described by Redfern and others (20).

Need for New Adhesives for Wood

In spite of the use of increasing quantities of glues in the wood-working industry and the availability of quite an array of adhesives at the present time, there remains a number of unsolved problems. Better glues are definitely needed to reduce cost and to generally make the production process more practical.

One of the intriguing new problems is the use of adhesives in bonding wood boxes and pallets for the packaging industry. The well-known advantages of glued construction for distributing stresses more efficiently from one member to another as compared to mechanical fastenings has naturally attracted the interest of the manufacturers and users of wood boxes and wood pallets. Both of these wood products are now facing severe competition from other materials.

Nailed wood boxes for fruits and vegetables, for example, have been steadily losing ground to corrugated fiberboard cartons. Since the market for wood in these containers represents a very important utilization outlet for some of the smaller sizes and lower grades of softwood lumber, it is important to find ways to improve them. It is felt that glued constructions, probably with somewhat different box design, may be the answer here. The U. S. Forest Products Laboratory sponsored a conference of box and pallet manufacturers and adhesive suppliers in Madison on April 1, 1958, to consider this problem (35).

The subject of end gluing lumber continues to be of great interest (21). End gluing must necessarily be a fast operation in order to achieve any sort of economical production. In addition there is a problem of bonding to various qualities of end-grain wood surfaces often not machined to the best possible gluing surface. The utilization of short pieces by gluing them into longer lengths for sale in competition with solid lumber requires fast-setting, strong, low-cost, and durable glue lines.

Another type of adhesive that is not yet available, is one suitable for bonding the skins of glued prefabricated wall panels to the framing members on a production basis without the use of presses or of nail gluing. This is one place where the contact adhesives would be particularly applicable, but as previously indicated these adhesives are not adequate for the purpose at the present time. A roller-pressure operation for bonding full-size wall panels on a continuous process would be of real interest here. Along this line is the continued interest in sandwich-type panels consisting of paper honeycomb cores and plywood or hardboard faces. The U. S. Forest Products Laboratory's sandwich test house has now been standing under test since 1947 and shows very good service. The primary structure of the walls and the roof of this house is of plywood, hardboard, and other wood-base skins bonded to paper honeycomb cores.

During the past year, more interest has developed in the overlaying of lumber with kraft paper, with or without resin treatment. Sometimes it is intended only to convert the smaller sizes of lower grades of lumber into standard panel sizes for easy erection as lumber sheathing, in competition with other sheathing panels. In this case the life of the glue bond need only be temporary, until the nailing is completed.

On the other hand, other types of paper overlay lumber, such as paper faced siding, require glue bonds of long-term durability under severe conditions. Although test samples of paper overlaid siding and other paper overlaid lumber products can be made with conventional phenol and resorcinol resin glues, these glues are not considered economical and suitable for large-volume production under present conditions, particularly when undertaken by new plants not experienced in gluing operations and without conventional gluing equipment. The development of new gluing processes for bonding paper overlays to lumber and to siding at the sawmill would play a very important part in upgrading lumber most effectively by masking the defects and producing a surface with better appearance and painting characteristics (36).

Interest continues in the laminating of 2 by 4's, both of the western softwoods and of southern yellow pine. The principles here involve the utilization of the lower grades of 1-inch lumber by laminating them into 2-inch stock and also producing higher grade material from the lower grade thinner lumber and producing material that is straighter than the conventional solid 2 by 4's (25). This type of operation would be expanded considerably by the development of a continuous bonding operation as is now practiced with the neoprene contact cements for binding plastic overlays to core stock. The laminating industry in general would profit by the development of better low-cost and durable adhesives for the production of exterior-type laminates under more practical factory conditions.

If the veneer-type flooring that is bonded directly to concrete or plywood subfloors, previously mentioned, is to enjoy broader use some further im-

Fig. 3.—Erecting large laminated arches for Jai Alai Fronton, West Palm Beach, Florida. Arches are 11 by 46 inches in largest cross section. Center rise is 74 feet. Courtesy: Unit Structures, Inc.

provements on the rubber-base adhesives now available will undoubtedly be required to insure adequate service.

Binders for Particle Board

The most common binder for particle board in this country and abroad has continued to be the urea resin. This type of binder apparently works adequately for particle boards to be used for interior applications such as core stock for furniture and millwork. To expand the market for particle board, much more interest during the past year has been directed towards the production of durable types of board suitable for more severe service, as in housing applications. For this, phenol resin binders are of particular interest. The actual serviceability of phenolic-bonded particle board, at the resin levels currently under consideration, has yet to be established. There is a good possibility that other types of binder materials may be used satisfactorily for the production of this more durable type of particle board, and their development should be encouraged. Attention is also being given to binders that will be compatible with fire retardants and preservatives incorporated in particle boards.

Interest continues in the molding of wood products from the fines produced in particle board and other woodworking operations. Toilet seats are the principal product, but other items include wooden bowls and various types of novelties. There is considerable interest in the possibility of molding table legs and other furniture parts as well as women's shoe heels and other items. Certain phenolic resins are the most common binders for such molded wood products. Resins with particularly good flow properties are apparently needed for such applications. Recently the use of blends of urea resin and phenolic resin in the molding of toilet seats has been reported to result in lower costs and faster curing than with the single-stage phenolic resins formerly used.

Bonding Techniques and Equipment

It is well known that the gluing techniques and the control of bonding conditions are often as important or even more important than the actual adhesive in influencing the initial dry quality of the glue bond. Therefore, continued study of the different variables in the bonding process with each new type of adhesive is an important consideration, as is also the development of improved bonding techniques and equipment for these bonding operations.

For example in the softwood plywood industry, which is geared to rather high-volume production, the bulk handling of synthetic resins is pretty much the rule. Lined tanks or tanks of corrosion-resistant material are frequently specified. Stainless steel tanks are usually the most suitable as far as over-all strength and corrosion resistance are concerned, but the cost may be prohibitive in some cases. Light-gage stainless steel tanks with exterior steel bracing are reported to provide excellent serviceability at a substantially reduced cost.

Bulk shipment of liquid plywood glues in collapsible rubber bags was recently announced (26). Flat bed trucks are used on the West Coast to haul plywood from the mill to the shipping center. After unloading, the huge rubber bag is rolled out on the truck, filled with resin, and hauled back to the mill. This eliminates two separate truck trips, each loaded in only one direction, and is reported to save about $200 each trip on a 300-mile run from northern California to San Francisco and return. Bags are reported to have the same capacity as a standard 5,000-gallon tank trailer.

The present feeling of many is that there is still much room for substantial improvements in glue mixing equipment. Extra-large sizes are not generally available. These are particularly needed for plywood production. Clearance between sides and rotating elements in mixers is often excessive, and temperature measurement and control in the mixing equipment is often inadequate. It is thought by some authorities that scraper blades on mixers should be used more generally.

Thought is being given continually, particularly in the plywood industry, to improving the spreading of glues. On the West Coast, two recent major changes in glue spreaders include the use of combination groovings and the use of new types of rubbers on the spreader rolls. With the fairly large segment of the West Coast plywood industry converting their cold-press operations to hot-press, there has been a sudden demand for a grooving on the spreader rolls that will satisfactorily spread both interior-type protein adhesives and exterior-type phenolic resin glues. With both interior and exterior plywood flowing through the same hot-press production line, it is no longer practical to have separate spreaders for the protein and phenol-resin glues. To combine the spread range of the protein glues (75–95 lbs. per M sq. ft. of double glue line) and phenol-resin glues (50–70 lbs. per M sq. ft. of double glue line) into one grooving that would deliver glue in the range of 50 to 90 pounds presented quite a design problem. This requires a design that would solidly grip the veneer crossbanding at high speeds, be flexible enough so that the roll pressure could sufficiently reduce spreads, and have good wearing properties. Such types of grooving are now reported to be available.

The second major change in the West Coast plywood industry in the past year has been the trend towards the wider use of Buna-n rubber in place of neoprene. The better wearability and durability of Buna-n rubber has been long recognized, but it was not until this year that it could be vulcanized to the spreader rolls without serious defects. This vulcanization process was reported as solved this year, and the conversion of Buna-n rubber for spreader rolls has become quite rapid.

In the field of new spreaders, the use of controls that operate by air pressure continues to be popular. The

use of air has the advantage of eliminating the slack found in mechanical linkages, and also allows the doctor bars and the spreader rolls to be rapidly changed to a new position and then quickly returned to their original position. The use of automatic glue levelers has found wider acceptance in the past year. There are several designs in use involving mechanical, electrical, and pneumatic controls. These glue levelers eliminate loss in production due to delays when the spreader hoppers are filled, eliminate accidental overflow of the spreader hoppers, and also prevent the hoppers from accidentally running dry, with the resulting manufacture of reject panels.

The softwood plywood industry is always thinking about a continuous process of production, and in this connection there has been considerable thought given to radically different methods of applying glue. None of the new techniques have replaced conventional spreaders in production lines, although the spraying of glue has been tested in a full-scale model. In one instance, an automatic core layer as an integral part of the glue spreader has been used successfully in the production line for the past year. Several large plywood concerns are reported to be working on more efficient layup procedures that will eliminate some of the high labor cost connected with this phase of production, and it could very well be that in a year or so a new design involving a spraying technique will be forthcoming.

During the past year, a great interest developed in the foaming of glues prior to spreading in order to control the glue spreads uniformly at low weight levels. This process is essentially not new, having been developed in Europe prior to World War II, but has not been considered or used extensively in this country until just recently. Two methods of foaming have been described and are under experimentation and further development. In one case, chemical foaming agents are incorporated and the foam is said to be more stable than when produced by whipping air into the resin. The chemical foaming technique has been used primarily on urea resins in the Eastern part of the country in plywood production (27).

A mechanical foaming technique that uses air with special foam-stabilizing agents has been described and is under investigation in the West Coast plywood industry. This involves primarily phenolic resin. The foam-stabilizing agents are said to be the secret for the effectiveness of this process, and specific foaming agents are used for each particular adhesive mix.

It is said to be possible to spread urea resins uniformly at a rate of only 15 pounds per 100 square feet of single glue line by means of the chemical foaming technique and ordinary glue spreaders. Such low spreads require flat smooth veneers and spreading equipment must be in excellent operating condition. There apparently is need for developing improved equipment for both the foaming techniques and for the groovings and other controls on spreaders for the proper use of the foamed glues.

The use of quick-operating air-hose presses for short press cycles (Fig. 1) and the use of roller presses (Fig. 2) continues to increase. The most recently installed plywood presses on the West Coast are reported to have 24 openings. Particularly in making particle board and hardboards, some of the manufacturers are considering going to 5-foot-wide platens for the future installations. Several hot-water-heated presses have appeared on the North American continent. There is some question as to whether such a system offers real advantages over a properly designed steam system.

A new splicer has been designed to use both conventional thermosetting resin adhesives and thermoplastic polyvinyl acetate emulsions. When the thermoplastic adhesive is employed, speeds up to 200 feet per minute regardless of stock thickness are reported. This is accomplished by a heated vertical strip, which applies heat only to the glued edge of the stock whereas conventional thermosetting adhesives are generally heated from above and below the stock.

A particle board press reported from Europe utilizes radio-frequency heating for preheating the mat and steam-heated platens to obtain final board cure. So far as is known, this type has not been tried in the plywood industry.

A continuous process for scarf jointing large plywood panels has recently been reported (28).

Improvements are reported in high-frequency-heated edge gluers. An interesting development reported is a veneer edge glue that does not require heating. Contact adhesives have been reported to be fairly successful when used in the standard veneer edge gluer with the heat off.

A new method of gluing and simultaneously heating and impregnating laminated structures has been reported (29).

New Glued Products

It is becoming more generally recognized by the entire wood industry that gluing offers one of the best methods of utilizing the lower quality woods, the less desirable species, and the smaller pieces from cutting operations, and that therefore the development of new glued products is likely to expand even further in the near future. This is very likely to be accentuated by the fact that customer preferences in wood products are going up while timber quality is continually going down.

As more and more of these glued products are substituted for solid wood items and used under the same conditions, the use of only durable glues becomes of greater interest. Employing glues of different levels of durability to make glued products that are used interchangeably with solid wood products is likely to result in unsatisfactory service of some of the glued objects if improperly used under severe conditions. Several forward-thinking wood products manufacturers are therefore using only durable-type glues in the edge and end gluing of panel lumber as well as in all laminates so that the glued products can be used for either mild or severe service. Trends are also in this direction in the softwood plywood industry, although it may be some years before the complete change to an all-durable type bond is made (4).

Edge- and end-glued lumber, previously mentioned, is of great importance and interest is likely to increase. The problem here is to use up the short lengths of the relatively high-grade material more effectively. Examples include such nonstructural items as door jams, window and door rails and stiles, architectural trim, and other millwork items. Further developments under consideration include end-glue siding where short lengths are reconstituted into standard lengths for greater convenience and for eliminating paint-holding and other problems when such joints are assembled on the job.

Edge- and end-glued panels of lumber have been produced recently for car lining as well as for various types of sheating material where its convenience of installation is a very important factor. Here the choice of glue, the gluing process, and the degree of control necessary over the gluing operation depend largely on whether the glue joints are intended only to hold the panels together until nailing is completed according to conventional nailing practices, or whether the entire panel is expected to act structurally as a single unit throughout the service life of the panel. There is no doubt that the edge and end gluing of these small pieces represents a very important utilization tool. In addition to simplifying the gluing process and the development of more adequate, lower cost glues, it is undoubtedly important to develop more

economical mechanized procedures to reduce the labor costs for handling these small pieces prior to gluing. Continued interest is noted in the development of improved designs for finger joints in order to achieve greater structural efficiency (21).

The development of laminated wood timbers for structural applications continue to increase (Fig. 3). There is, apparently, a trend to the use of a larger proportion of resorcinol resin in such laminates than in previous years. One authority estimates a ratio of 2:1 for casein over resorcinol and phenol-resorcinol resins in structural laminates at the present time.

A more efficient finger joint is particularly needed in the construction of structural laminates. New developments include combinations of different species in a single laminate as, for example, roof decking with a selected lumber face for the exposed surface or laminated arches with veneer faces.

The formulation of a more practical low-cost laminating glue that would permit the production of laminated members of a single, durable quality would be a big boost for this industry. Gluing of treated wood for structural laminates like bridge timbers continues to be an important part of the laminating industry. A new method of gluing and simultaneously heating and impregnating laminated structures has been described (29).

An I-beam has been developed in Germany in which the flanges are made of solid wood and the web of plywood. The edges of the wave-formed plywood are glued into similarly formed grooves in the upper and lower flanges. The beam lends itself to continuous production, and has been made from 14 to 42 centimeters high and 6 to 14 centimeters in width, with flange thicknesses ranging from 3 to 6 centimeters. More than 300,000 running meters of such beams are said to have been produced (30).

An increased interest in the bonding of vinyl overlay materials to plywood, particle board, and hard board substrates was reported during the past year. Although the basic technique is not entirely new, this year there seemed to be a significant increase in the variety of overlay materials offered on the market. At present, each overlay material presents a somewhat different gluing problem because no single adhesive, such as the contact cements for example, has the ability to adhere all vinyl overlays to the substrates. This problem will require the development of special products by the adhesive manufacturers.

The production of veneered particle board is reported to be increasing, particularly in Canada. In addition to furniture applications, it is now being produced in increasing amounts with face veneers of different decorative species for uses as wall paneling, kitchen cupboards, and similar applications. In Canada these products are being bonded primarily with urea resins.

Production of hardwood plywood in Canada in which the birch face veneers are chemically treated prior to gluing to produce special color effects is also reported to be increasing.

Test Methods and Standards

Along with these activities in the upgrading of wood is the recognition of a need for better quality control and evaluation of the glue bonds.

One of the most significant developments during the past year was the proposed change in the glue-joint requirements for interior-type Douglas-fir plywood, now under consideration as a revision of Commercial Standard CS45–55. The new test specifies a 2- by 5-inch specimen in place of the 6- by 6-inch specimen and subjecting it to 3 cycles, each consisting of 4 hours' soaking in water at normal room temperature and of 20 hours' drying at a temperature of 100 to 105° F. under some forced air circulation. The test is expected to be more reproducible and somewhat more effective in detecting inferior glue bonds. The Douglas Fir Plywood Association is reported to be planning to use this revised method in their own plant inspection tests beginning in the first quarter of 1959.

The American Institute of Timber Construction is developing standards for structural glued laminated lumber, and a quality control and inspection system for its production and certification. The Southern Pine Inspection Bureau is developing standards for laminated lumber with a thickness of four inches and less. The Canadian Institute of Timber Construction also has developed and installed quality control standards and procedures.

The well-known vacuum-pressure delamination test procedure for laminated timbers was recently revised to simplify the test procedure, and has now been accepted by ASTM as their Standard Method of Test for Integrity of Glue Joints in Laminated Wood Products for Exterior Service, D1101–58.

The search for better short-term tests for evaluating glue joints, particularly in plywood, continues. Important new developments have been the introduction of highly accelerated tests for water-resistant hardwood plywood (31) and rapid delamination tests for Douglas-fir plywood (32). Both of these methods involve automatic cycling equipment in order to handle the time scheduling more efficiently. Somewhat more severe drying conditions are provided so that the cycles can be shortened. Automatic cycling equipment for soaking and drying tests is already reported to be in use for routine evaluation and quality control at the plant level.

The glue line cleavage test particularly adapted to determining the gluability of hardboard has been described (33).

The question of adequate evaluation of the type and amount of wood failure in broken test specimens has received further consideration (34).

The Ottawa Laboratory of the Forest Products Laboratories of Canada has recently announced a sonic device for inspecting glue bonds in plywood and other multilayer materials. The device is reported to detect any area where an inner glue bond is defective, for instance the presence of hidden blisters. It is reported that after two years of research and development, an instrument has been perfected that will detect and mark the location of a blister or other defective bond between the innermost plies of Douglas-fir plywood up to ¾ inch thick. The detector unit consists of a rotating brush assembly, which excites sonic vibrations in the plywood. Some of the sound produced by the vibrating plywood is picked up by the sensitive microphone located inside the rotating brush, converted into electrical energy, and fed to an electronic circuit, this circuit responds to a difference in the nature of the sound produced when the detector passes over a blister, and causes a mark to be made on the plywood over the blister.

Greater interest in development of test methods for wood adhesives may be expected by the activities of the new Subcommittee X of ASTM Committee D–14 previously mentioned.

1958 Bibliography

1. Marian, J. E., D. A. Stumbo, and C. W. Maxey. 1958. Surface texture of wood as related to glue joint strength. Forest Prod. J. VIII (12): 345.
2. Bodnar, M. G., and W. H. Schrader. 1958. Bonding properties of a solvent-less cyanocrylate adhesive. Modern Plastics 36(1): 142.
3. Rose, A. 1957. Chemical control of hot press urea formaldehyde glue mixes. Forest Prod. J. VII (11): 30A.
4. Anon. 1958. Plywood plans change adhesives outlook. Chemical Week 83(21): 65.
5. Williamson, F. L., and W. T. Nearn. 1958. Wood to wood bonds with epoxy resins-species effects. Forest Prod. J. VIII (6): 182.

6. Narayanamurti, D., R. R. Rau, and R. Ram. 1958. Adhesives from tannins in the bark of bruguiera species. Tropical Woods 109: 54.
7. Herrick, F. W., and L. H. Bock. 1958. Adhesives from bark extracts. Forest Prod. J. VIII (10): 269.
8. Marian, J. E., and A. Wissing. The utilization of bark III. The utilization of polyphenols from spruce bark extractives in adhesives. (In preparation)
9. Plomley, K. F., J. W. Gottstein, and W. W. Hillis. 1951. Tannin formaldehyde adhesives. Forest Prod. Newsletter, CSIRO, Australia, 234: 6–8.
10. Narayanamurti, D., R. R. Rau, and R. Ram. 1957. Adhesives from Tamarind seed hulls. J. Sci. Indus. Res. (India) B. 16: 337.
11. Wissing, A. 1958. Bark as a source of raw material. Swed. Forest Prod. Res. Ind. Medd. 97B, Stockholm, Sweden.
12. Marian, J. E., and A. Wissing. 1957. The utilization of bark I. Index to bark literature. Swed. Forest Prod. Res. Inst. Medd. 90B, Stockholm, Sweden.
13. Prasad, B. M. 1957. Chipboards from Indian timbers. Res. and Indus. India. 2: 293.
14. Dhamaney, C. P. 1957. Adhesives from cashew shell oil. For. Res. Inst., Dehra Dun, India. Paintindia, J. 2: 29–31.
15. Narayanamurti, D. 1957. Adhesives from seed proteins and seed cakes. I.C.A.R. Research Series No. 12. (Indian Council Agricultural Research)
16. Nico, Raul. 1956. A wood adhesive from residual peanut meal. Lab. ensayo materiales e invest. technol. Prov. Buenos Aires, Argentina. Ser. II. 64: 18 (English summary)
17. Zuchowski, W. 1955. The solubility of albumins as criterion for suitability for plywood-glue manufacture. Przemysl Drzewny 1954, No. 12: 14–16. Polish Techin. Abstr. No. 3892 (1955).
18. Takashima, J., K. Ariga. 1958. Blood glue XII. Mokuzai Gakkaishi 4: 10–14. (Tokyo Univ. Agr. Jourl.).
19. Zabrodkin, A. G., and E. K. Artishevskaya. 1958. Use of crude phenols for water-soluble phenol-formaldehyde adhesive. Derevoobrazyvayushehaya Prom. 7. 2: 18.
20. Redfern, D. V., and G. F. Baxter. 1957. Monohydric phenol-aldehyde-sodium silicate wood glues. American-Marietta Co. U.S.P. 2, 813, 082.
21. Richards, D. B. 1958. End gluing lumber. Forest Prod. J. VIII (3): 99.
22. Estep, M. H. 1958. Survey of adhesives for edge and end gluing. Forest Prod. J. VIII (10): 55A.
23. McSwain, G. A. 1958. Design economics and related properties of end and edge glued joints commonly in use. Forest Prod. J. VIII (8): 23A.
24. Heinzelman, K. J., Jr., 1958. Dielectric and high frequency heating for finger jointing. Forest Prod. J. VIII (2): 41A.
25. McKean, H. B., and J. W. Smith. 1958. Pilot planting laminated 2 x 4's. Forest Prod. J. VIII (8): 19A.
26. Anon. 1958. Big rubber bags turn flat-bed trucks into tankers, cut costs. Wall St. Jour., Dec. 11, p. 1.
27. Bornstein, L. E. 1958. Chemical foam extension of urea formaldehyde glues. Forest Prod. J. VIII (8): 17A.
28. Knokev, E. R. 1958. Continuous method of scarf jointing plywood panels. Forest Prod. J. VIII (8): 17A.
29. Perkitny, J. 1958. A new process of a quick-hot gluing and simultaneous impregnation of laminates. Holz a.R.uW. 16 Jg. Heft 3:97–101. Br. P. 716, 347. Swed. P. 145, 329. Swiss P. 302, 639.
30. Stoy, Von W. 1958. Successful experiment on large series of manufacture of glued structural wood elements. Holz, Als. Roh und Werkstoffe 16(7): 274.
31. Hart, C. A. 1958. Development of a highly accelerated test for water-resistant hardwood plywood. Forest Prod. J. VIII (4): 113.
32. Campbell, O. F. 1958. Rapid delamination test for plywood. Forest Prod. J. VIII (4) 118.
33. Northcott, P. L. 1958. Glue line cleavage test applied to hardboard glueability. Forest Prod. J. VIII (3): 36A.
34. Northcott, P. L. 1958. Wood failure —within species and between species. Forest Prod. J. VIII (6): 180.
35. Anon. 1957. Six million pound opportunity for adhesives. Chemical Week, 81(25): 41.
36. Heebink, B. G., R. J. Seidl, D. F. Laughnan, and R. F. Blomquist. 1955. Some potentials of overlaid lumber. Forest Prod. J. V (4): 97.

1957 Bibliography

1. Anon. 1957. The durability of wood adhesives in light naval craft. Timber Tech. 65 (2211).
2. Anon. 1957. The expanding domain of expoxy resins. Adhesives and Resins 5(1): 1–3.
3. Anon. 1957. Glues for woodworking. Adhesives and Resins 5(1): 6.
4. Anon. 1957. Instrument measures solids contents of glues. Adhesives and Resins 5(1): 10.
5. Anon. 1957. Monomethylol dimethyl hydantoin, an odorless formaldehyde donor. Adhesives and Resins 5(3): 29–30.
6. Anon. 1957. Mixing and utilization of casein glue. Veneers and Plywood. 51(3): 24.
7. Anon. 1957. Silicones for foam prevention. Adhesives and Resins 5(4): 44–45.
8. Anon. 1957. The wet lay-up technique. Adhesives and Resins 5(5): 55.
9. Anon. 1957. A new laminating resin. Adhesives and Resins: 5(6) 74–76.
10. Anon. 1957. Corrosion-proof cement and membrane incorporating epoxy resin. Adhesives and Resins. 5(9).
11. Anon. 1957. Casein glued laminated roof arches for church reconstruction. resin. Adhesives and Resins. 5(7).
12. Anon. 1957. Form gluing of plywood has improved. Veneers and Plywood 51(9): 17.
13. Anon. 1957. Glues and gluing. Veneers and Plywood. 51(10) 29.
14. Anon. 1957. New adhesives plus infra-red heating speeds production of laminates. Adhesives and Resins 5(11): 138–139.
15. Anon. 1957. New glue spreader has simplified lamination with contact adhesives. Veneers and Plywood 51 (11): 38.
16. Angleton, H. D. 1957. How to nail-glue hardwoods and softwoods. Purdue Univ. Agricultural Ext. Service. Ext. Circular 441.
17. Baker, A. 1957. The tropical durability of wood assembly adhesives (Final note). Technical note, Royal Aircraft Establishment, Farnborough No. Chem. 1294.
18. Blomquist, R. F., and W. Z. Olson. 1957. Durability of urea-resin glues at elevated temperatures. Forest Prod. 7(8): 266–272.
19. Booth, C. C., and J. W. Maxwell. 1957. How long will it last—a study of glue line durability. Forest Prod. J. 7(6): 187–195.
20. Brouse, D. 1957. The ideal glue—how close are we? Forest Prod. J. 7(5): 163–167.
21. Bune, A. J. 1957. The compatibility of wood preservatives and glues. Timber Tech. Vol. 65, (2220) 1
22. Clarke, J. T., and W. T. Sharn. 1957. Factors affecting the quality of an epoxy resin wood-to-wood bond. Forest Prod. J. 7(1): 20–27.
23. Coufal, J. 1957. The forward look in gluing. Forest Products Journal 7(2): 36A.
24. Coufal, J. W. 1957. Gluing and fabricating flush doors. Forest Prod. J. 7(3): 26A–29A.
25. Curry, W. T. 1957. The strength properties of plywoods. Part 3. The influence of the adhesive. Forest Products Research, London. Bulleti. 39.
26. Dhamaney, C. P. 1957. Adhesives from cashew shell oil. Paintindia 7 (2): 29–31.
27. Eby, R. E. 1957. Developments in structural glued laminated construction. ASTM. Special Tech. Pub 209.
28. Eickner, H. W. 1957. General survey of data on the reliability of metal-bonding adhesive processes. Forest Prod. Lab. report 1862.
29. Forest Products Laboratory. 1957. Synthetic resin glues. The Australian Timber Journal 23(5): 60–94.
30. Forest Products Laboratory. 1957. Tooth-planing not necessary to produce strong glued wood joints. Tech. Note 227. Rev.
31. Fromm, H. 1957. Kunstharzveredelte faserplatten. Holztechnik 37(1): 5–6.
32. Fysh, D. 1957. Conference on gelatin and glue research. Adhesives and Resins 5(9): 99.
33. Goldblatt, L. A., L. L. Hopper, and D. L. Wood. 1957. Epoxy resin esters containing tung oil fatty acids. Industrial and Engineering Chemistry 49(7): 1009–1102.
34. Hinken, E., and A. A. Marra. 1957. A study of some factors affecting the gap-filling properties of wood adhesives. Forest Prod. J. 7(9): 286–292.
35. Horioka, K., and M. Noguchi. 1957. Studies on plywood. Report 7. On the formaldehyde gas emitted at curing and using of plywood glued with urea-formaldehyde resin adhesives. Forest Expt. Station, Meguro, Tokyo. Bulletin 98.
36. Marian, J. E. 1958. Adhesive and adhesion problems in connection with particle board production. Forest Prod. J. 8(6): 172.
37. Marian, J. E., and K. Suchsland. 1957. Experimental investigation of gluing and finishing problems through application of fluorescence microscopy in incident light. Forest Prod. J. 7(2): 74–77.
38. Marra, Alan A., ed. 1957. Developments in glues and gluing. I. Richard F. Blomquist. Adhesive II. Carl F. MacLagan. Gluing techniques and glued products. III John Keitler. Methods of test. IV. Robert Williams. Gluing equipment. V. Jan S. Bethel. Current research. VI. V. Poletika. Patents. VII. Ben S. Bryant.

Bibliography. Forest Prod. J. 7(2): ...-44.
39. ...eakin, K. S. 1957. Synthetic resin ...es in structural design. Part 2. Wood 22(10): 404.
40. ...ller, D. G., and T. J. Cole. 1957. ...electric properties of resin glues ... wood. Forest Prod. J. 7(10): 345.
41. ...argyuerm, S. 1957. Application des ... thodes de chromatographie et ... lectrophorese a l'identification et a ... analyse des gommes naturelles. Inst. ... xtile de France. B. 1957. (67): ... 43.
42. ...usser, H. 1957. Experiments with ...e extenders for urea resins. Can... Forestry Branch. Forest Prod. ... Division. Trans. 116.
43. ...kitin, N. I., S. D. Antonovskii, and M. A. Mikhailova. 1957. Production of synthetic resins from lignin by the action of acetylene in the presence of alkali. (In Russian) Zhur. Prikl. Khim. 3095: 750–763.
44. Northcott, P. L. 1957. The effect of dryer temperatures upon the gluing properties of Douglas-fir veneer. Forest Prod. J. 7(1): 10–16.
45. Rauch, A. H. 1957. Glue spreading by spraying method. Forest Prod. J. 7(3): 105–9.
46. Reed, H. B. 1957. Production gluing of random-length core stock. Forest Prod. J. 7(10): 352.
47. Rhude, M. J. 1957. Quality control in the production of laminated timbers. Forest Prod. J. 7(3): 100–105.
48. Rice, J. T. 1957. Effect of angular loading on glue line strength. Forest Prod. J. 7(6): 196–199.
49. Rose, A. 1957. Chemical control of hot-press urea-formaldehyde glue mixes. Forest Prod. J. 7(11): 30A–33A.
50. Sherrer, R. E. 1957. Stresses in a lap joint with elastic adhesive. Forest Prod. Lab. Report 1864.
51. Susicky, K. 1957. Polyvinylazetatklebestoff in der Bleistifterzeugung und einge weitere Möglichkeiten seiner Verwendung. (In Czech) Dvevo 12(2). 36–39.
52. Swann, G. 1957. Modified polyamide resins. Adhesives and Resins 5(3): 31–34.
53. Takashima, Tojun, and Kazuhiko Ariga. 1957. Researches on blood glue. XI. On the difference of gluing strength of blood constituents. Japan Wood Research Soc. J. 3(2): 71–74.
54. Walsh, R. 1957. The use of resin adhesives in combining corrugating board. (Abs.) Southern Pulp and Paper Manufacturer 20(4): 72.
55. Welling, M. S. 1957. Polyvinyl chloride resins. I. Vinyl polymers and copolymers. Adhesives and Resins 5 (9): 105–110.
56. Welling, M. S. 1957. Polyvinyl chloride resins. II. P.V.C. paste resins (paste formulation). Adhesives and Resins 5(10): 116–124.
57. Welling, M. S. 1957. Polyvinyl chloride resins. III. P.V.C. paste resins (processing). Adhesives and Resins 5(12): 147–157.

Progress in Logging—1958

F. C. Simmons
Chairman, FPRS Logging Division[1]

Loggers can expect the 1958 upswing to continue in 1959. Cost and quality control practices were emphasized the past year; again, larger and more versatile equipment was developed.

Fig. 1.—This logging transporter for rough skid trails has a payload capacity of 30 tons. It has an electric motor geared directly to each wheel, and uses no clutches, mechanical drives, or body springs. Photo courtesy LeTourneau.

Conditions improved for loggers in both Canada and the United States during 1958. At the beginning of the year, many operations were shut down, and others operating on a skeleton basis, because of poor markets. An upturn in business by midsummer threw many operations into high gear, because manufacturers were complaining about inadequate supplies of logs, due to the curtailment of logging the previous winter.

Generally good weather conditions prevailed during the late summer and fall, and considerable log inventories were accumulated. The good fall weather was abruptly terminated in the Intermountain Region by a violent windstorm Nov. 3. The extent of the blow-down has not been assessed as yet, but it is thought the damage was considerable. The area had been striving to clean up hot spots of insect infestation from blow-downs of several years ago, and it is felt that this new situation will again develop serious insect infestation in areas not accessible to salvage logging. High winds, some of tornado intensity, were also experienced in the mid-South and the

[1] Members of the Technical Committee of the Logging Division who contributed to this report include: Emanual Fritz, Foundation for American Resource Management; Robert Olin, Potlatch Forests, Inc.; and Jerome Doyle, Ottawa Laboratories, FPL of Can., Ltd.

The Author: Fred Simmons received his BS from Cornell, and his MF from Yale. He is now Specialist in Logging and Primary Processing, Northeastern Forest Exp't. Station, Upper Darby, Pa.

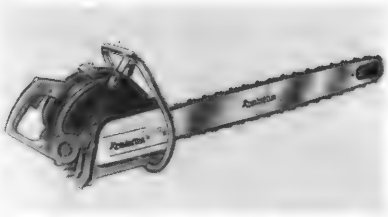


Fig. 2.—One of the new 7 hp direct-drive chain saws. It has full load chain speed of 2800 fpm. Photo courtesy Remington Arms.

Central States, as far north as Wisconsin.

The outlook for 1959 is for better conditions in the logging industry generally. With increased housing construction in both Canada and the United States, demand for both saw and veneer logs is good. There has been some firming up of prices for these commodities, generally through a tighter application of log grades. Demand for pulpwood is also reviving as a result of inventory reduction in the pulpmill wood yards. Several new mills have come into the market, and some of the older ones have increased their capacities. On the other hand, a few of the oldest and least efficient pulpmills have discontinued operations and caused loss of markets in their localities.

Technological Developments

Cost control and quality contral are major concerns among logging operators and purchasers of logs throughout the two countries. A paper presented at the FPRS National Meeting at Madison in June, 1958, by L. G. Lussier of the Woodlands Division of the Quebec North Shore Paper Co. on "Systematic Planning and Control of Forest Operations" aroused much interest. It described the application of the principles of Operations Research, now so widely used in other types of business, to logging operations. According to Mr. Lussier, the application of a planning and control system, derived from Forest Operations Research techniques, increased pulpwood hauling production with mechanical equipment by 40 per cent on the average, and sometimes as much as 75 per cent. Another paper, presented at the same meeting by C. R. Lockard of the U. S. Forest Service, was on "Scientific Timber Quality Evaluation—A Lumber Industry 'Must' ". It emphasized the need for, and usefulness of, scientifically based log- and tree-grading specifications in timber stand appraisal, in log making, and in log purchasing programs.

As a result of such technological advancements, and also of the current increasing use of complicated and expensive machinery, logging is becoming a more specialized business. Captive and company operations must be staffed with more competent and better educated personnel, who occupy more responsible positions in the company hierarchy. And more and more of the logging jobs for smaller concerns are being contracted out to responsible and progressive independent logging operators, who have the necessary knowledge and equipment to run an efficient job. This is a big advantage, because such independent operators, running several jobs simultaneously, can use expensive but efficient specialized machinery, such as tractors, loaders, and roadbuilding and maintenance equipment, more nearly full time than would be possible on almost any individual small job.

Another result of technological developments in logging is that several eastern universities are working toward the establishment of courses in logging engineering, on a graduate level.

New Machinery

One of the more interesting developments in Canadian logging during the year was the trial of a new machine called the "Pope Timber Harvester." The machine operates like this, quoting a recent description: "It stalks into the woods, grabs a tree, saws it, limbs it, and bucks it into lengths. Mounted on a Caterpiller D–7 tractor, the "Harvester" incorporates two hand-like jaws, one a main jaw capable of rotating approximately 100 degrees, and the other a limbing jaw, mounted on a track on which it can slide. The third component is a hydraulically operated chain saw, which rotates with the main jaw. The machine has been undergoing field tests on the limits of the North Western Pulp and Power Co., Ltd., and limited trials have shown that the idea is entirely practical and sound.

A machine to skid, limb, debark, buck, and pile softwood pulpwood in one continuous operation is also being developed in the United States by Larson Hydraulics Co. of Ely, Minnesota.

Use of direct-drive chain saws, and four - wheel - drive, four - wheel - steer skidding tractors, with integral arches, mentioned in last year's report, continues to increase in both countries. Many models of the direct-drive saw are now available, in the six horsepower plus classification (Fig. 2). Such saws have been adopted as standard equipment on many logging jobs that cut large-sized trees, both of hardwood and soft-wood. It has been found that, when a careful and precise job of fitting the saw teeth is done, and the operators learn to handle the machines correctly, the direct-drive saw is a much safer, more productive, and more versatile tool than the old-reduction-drive models.

The wheeled tractors are also proving to be highly versatile and productive machines, when used properly. Because they incorporate an integral arch, they are more maneuverable than comparable crawler tractor machines with a trailing arch. During the year, two such integral arches appeared on the market as accessories for popular models of crawler tractors.

Both crawler and wheeled machines have their specialized fields of usefulness in woods work, but the wheeled machine is generally exceeding expectations wherever a serious and studied attempt is made to take advantage of its generally higher speeds, maneuverability, and log-lugging power in woods work. On many jobs in rough country, the crawler-track machines are being used for initial off-the-road bunching, and the rubber-tired machines then take over, and skid the prebunched loads over rough and inexpensively-constructed woods roads to the truck road or stream side (Fig. 3).

For loading on the truck, many special types of clam shell or grapple buckets are appearing, especially in the light-weight types (Fig. 4). These grapples not only increase the rate at which logs can be loaded, but they also reduce manpower requirements and substantially reduce log damage in handling, as compared with the tongs or logs grabs previously used. Progressive operators are finding it essential to elevate the crane operator's cab and controls several feet above the conventional position, so that the operator can have adequate visibility and control of log movement. Another device being used by some is the direct clutch-controlled tag line instead of an air-operated or spring-controlled tag line to control the grapple and log position when swinging. This intensive effort to improve log loading efficiency with mobile cranes is paying off in reduced cost and greater safety to workers.

The trend to bigger and sturdier log hauling trucks continues (Fig. 1). One ingenious logging superintendent in the Intermountain Region, operating on rough terrain and private roads, found himself in the position of having to transport single-length logs with double-length log equipment. He was using dual-axle trucks and dual-axle trailers. By arranging special bolster and trailer-tongue attachments, he made it possible to use the dual-axle trailers and carry a full load of single-length logs. Thus the truck carried its 16-foot load, and the trailer carried another independent full load, and the vehicles were still able to operate over

the extremely sharp curves in much better fashion than trailers with conventional steering. The real merit of the job lies in the fact that he can quickly and cheaply convert the entire piece of equipment back to double-length logging units when the equipment is moved to another job.

The application of forest products mobile radio systems to logging operations is still growing (Fig. 5). Many companies are adding to their systems or improving operation through technological improvements. The Intermountain area was favored in the fall of 1958 by a visit of Federal Communications Commissioner Rossel Hyde. The Commission spent three days studying radio and communication problems in the remote forests of the Bitter Root Mountains. He saw first hand the vital job mobile radio is doing in this area, together with the total lack of other types of communication and the impossibility of wire line installation and maintenance in such rugged forest terrain.

Barking pulpwood with portable barkers at sites remote from the mill is now being done on a commercial scale by at least five companies in eastern Canada. The basic machine in each case is a Cambio barker, mounted on skids, or made portable by other means. This developement will undoubtedly promote a wide use of full-tree logging methods.

In the Redwood Region of the U. S., more and more oversized logs are being halved or quartered, by ripping them with chain saws, on the logging operations. Costs of this ripping average about $5 per M. It is made necessary by the use of lighter and more mobile logging equipment, but it also results in less cracking of the logs enroute to the mill, and in the production of more vertical-grain lumber at the mill, which can be sold at a higher price than flat-grain material.

Fig. 3.—Grades up to 28 per cent are taken in stride by this 4-wheel-drive electric arch as it brings logs down a winding skid trail. Photo courtesy LeTourneau

The possible use of helicopters in logging operations in the two countries was quite thoroughly covered in a special session at the annual meeting of FPRS and reported in the September issue of the FOREST PRODUCTS JOURNAL.

Research Under Way

The studies of utilization of hardwood logging residues at Michigan College of Mining and Technology, and of costs of timber harvesting by the Forest Products Laboratories of Canada, mentioned in previous reports, were continued during the year. The staff of the Canadian institution spent six weeks during the summer on a highly-mechanized operation conducted by Hay and Co. Equipment included two bunching tractors, a Blue Ox wheeled skidder, and a Traxcavator loader. Trees were bunched and skidded in full merchantable lengths, and then were bucked into logs at the landing.

A research program recently initiated by FPL of Canada is aimed at determining the costs of removing from the forest residual trees not normally removed in logging, but which should be removed for the silvicultural good of the stand. This project is a joint venture between the Laboratory and the Ontario Department of Lands and Forests.

Data on damage to residual trees resulting from logging by several different methods, over a ten-year period on the Fernow Experimental Forest in West Virginia, were published by the Northeastern Forest Experiment Station near the close of the year. These logging operations were conducted on large-scale compartment management studies, in all-aged hardwood stands, in rough mountain country. The data shows that skidding damage was neg-

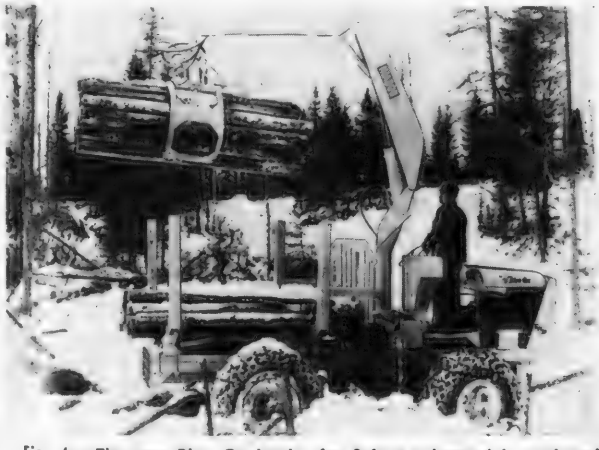


Fig. 4.—The new Blue Ox loader for 8-foot pulpwood is equipped with hydraulically controlled grapple. It can move at least 40 cords a day from a pile in the woods to truck or railroad car 1,000 feet away. Photo courtesy Four-Wheel-Drive.

Fig. 5.—This crawler tractor, equipped for fire-line construction, has a mobile radio so the operator can receive instructions from observers in aircraft overhead. Photo courtesy International Harvester.

ligible, even on selectively cut areas where about one-third of the sawlog volume was removed and where tree-length skidding was practiced. Damage generally amounted to less than 2 per cent of the intended residual stand, while felling damage in the same areas amounted to about 3 per cent of the residuals. Loggers on this operation, of course, were trained and supervised to keep logging damage at a minimum while at the same time attaining reasonable productivity.

The exploratory study of the current status of log and tree grade specifications by the U. S. Forest Service was completed, and a report issued. The Forest Service set up a new unit in the Division of Forest Products Utilization Research in the Washington office to provide general supervision for a nation-wide project of testing and perfecting existing grade specifications, and developing new grades where they are needed.

Meetings

The various organizations interested in progress in the logging subject-matter field held their usual well-attended and successful meetings during the year. These include the various regional Logging Congresses, meetings of the lumber trade associations and technical committees of the American Pulpwood Association, and sessions at the National and Sectional meetings of FPRS. The proceedings of several of these are included in the bibliography[2] that follows. This is again organized according to the "Oxford System of Decimal Classification for Forestry."

31. Logging and Transport (General)

31(73) United States

Carlson, T. A. Redwood region changes during past decade. Pacific Logging Cong. Loggers Handb. 17: 14–15. 1957.

Egerton, J. O. Notes on a tour of American logging and milling operations. 2. Malayan Forester 20(2): 91–98. Apr. 1957.

Kerr, E. F. They spawned a timber empire. South. Lumberman 195(2441): 117–120. Dec. 15, 1957.

Pacific Logging Congress. Official proceedings, Pacific Logging Congress, 47th session, San Francisco, Cal., Nov. 12, 13, 14, 1956. Pacific Logging Cong. Loggers Handb. 17(sect. II): 1–93. 1957.

Rogers, D. H. Public attitude toward logging and is the public going for it? Pacific Logging Cong. Loggers Handb. 17(sect. III): 2–3. 1957.

Simmons, F. C. Developments in logging —1957. Forest Prod. J. 8(2): 33–37. Ref. Feb. 1958.

Smith, J. L. Early lumbering days in the Chemung Valley. Noeast. Logger 6 (11): 20–21, 39, 45. May 1958.

[2] Compiled from the "Bibliography of Agriculture", U.S.D.A. Library.

U. S. Forest Serv., Forest Prod. Lab. List of publications on logging and milling, and utilization of timber products. U. S. Forest Serv., Forest Prod. Lab. Rpt. 790, 21 p. May 1958.

Webb, B. The old gives way to the new. South. Lumberman 196(2444): 54, 56. Feb. 1, 1958.

Whisnant, A. Logging lodgepole pine on pumice ground. Pacific Logging Cong. Loggers Handb. 17: 9–13. 1957.

31(71) Canada

Bennett, W. D. Logging atlas of eastern Canada. Pulp and Paper Research Institute of Canada. Montreal, 1958. Various paging. (Woodlands Research Index, 103).

British Columbia. Forest Serv. Half-yearly register of timber, handloggers' and log salvage marks.
v. 1, No. 146. Victoria, 1957. 433 p.
v. 2, No. 146. Victoria, 169 p.

Harrison, H. A. Bush operations mechanized by Newaygo. Timber Canada 19 (5): 24–26, 28. May 1958.

Hecht, M. R. Outlook for logging & lumber. Canada Lumberman 77(12): 28–32. Dec. 1957.

Hutchinson, I. Some aspects of logging in the coast forest of British Columbia. Empire Forestry Rev. 37(91, i.e.l.): 66–84. (Cont.) Mar. 1958.

Hutchinson, I. Some aspects of logging in British Columbia. II. Empire Forestry Rev. 37(92, i.e.2): 165–187. Ref. June 1958.

Wellwood, R. W. B. C. interior is catching up with the coast. Canada Lumberman 77(11): 56–58. Nov. 1957.

31(4) Europe

Bowles, W. D. Soviet loggers face several problems. Timberman 58(10): 33, 86. Sept. 20, 1957.

Jackson, S., and Owsley, C. Over the Iron Curtain and into the woods. Amer. Forests. 64(4): 14–18, 46, 48, 50–55. Apr. 1958.

Leclair, W. J. Logging and lumbering in Russia. Natl. Hardwood Lumber Assoc. Year Book & Dir. Hardwood Adver. 1956: 149, 151, 153, 155.

Pinkerton, M. Timber and logging techniques behind the Iron Curtain. Natl. Hardwood Mag. 31(10): 20–21, 25. Nov. 1957.

Richards, E. G. Forest workers in the U.S.S.R. South. Lumberman 196(2450): 31–32. May 1, 1958.

Sundqvist, J. Logging in days gone by. Finn. Paper & Timber 8(4): 62–63. 1957.

31(5) Asia

Bhattee, S. S. Logging in the Andamans. Indian Forester 84(4): 197–212. Apr. 1958.

Tamworth, I. P. A review of the methods of organizing exploitation in the tropical rain forests of Malaya. Malayan Forester 20(2): 67–71. Apr. 1957.

31(8) South America

Dow, L. E. An experiment at co-operative logging in British Guiana. Empire Forestry Rev. 37(92, i.e.2): 188–199. June 1958.

31(9) Oceania

Guerrero, F. A. Logging equipment suitable for selective logging. Lumberman (Manila) 3(2): 25, 27. Apr./May 1957.

Herold, E. W. Something different in logging in the Philippines. Pacific Logging Cong. Loggers Handb. 17: 17–23. 1957.

311. Planning of Logging Operations

Doyle, J. A. Effect of tree size of spruce and balsam fir on harvesting and conversion to lumber in Nova Scotia, Canada. Dept. North. Aff. & Natl. Resources. Forest Prod. Lab. Div. F.P.L. Tech. Note 5, 30 p. 1957.

Simmons, F. C. Engineering efficiency in logging and milling. South. Lumberman 195(2441): 121–124. Dec. 15, 1957.

Steinlin, H. J. One-man work in mixed stands of beech, spruce and fir. Food & Agr. Organ. United Nations. European Forestry Comn. FAO/EFC/LOG/55, 70 p. Ref. July 1957.

Wilson, A. K., and Greenway, G. H. Costs of logging virgin ponderosa pine in central Idaho. U. S. Forestr Serv. Intermountain Forest & Range Expt. Sta. Res. Paper 51, 15 p. June 1957.

313. Logging Mechanization

Guerrero, F. A. Selective loggin and sawmill equipment. Lumberman (Manila) 3(4): 15, 24. Aug./Sept. 1957.

Horncastle, D. C. Progress Report n full tree logging. Pulp & Paper Mag Canada 59(5): 163–164, 166. May 1958.

McColl, B. J., and Pepler, W. A. ... The development of mechanical pulpwood logging methods for Eastern Canada. Condensed ed. Canad. Pulp & Paper Assoc. Woodlands Sect. Index 1325 (B-1), 20 p. Oct. 1957.

Northeastern Loggers' Congress. New methods and new machinery. Noeast. Logger 6(2): 26–29, 65, 77. Aug. 1957. Contents: "Jack it down" by E. Wyman; New wheeled skidding tractor, by A. L. Lado; "Beaver" log debarker, by A. A. Ringland; "Bark-lasse" portable debarker, by R. Walby.

Peterson, W. H. Engineering of forestry utilization activities. New Zeal. Engin. 13(6): 211–212. June 15, 1958.

Simmons, F. C. Engineering approach to logging and milling. Forest Prod. J. 8(7): 14A–18A. July 1958.

Swift, M. At work in the woods; biggest-ever forestry demonstration features new machines that can ease and speed the woodman's jobs. Pract. Power Farming 21(1): 10–11. July 1958.

Walbridge, T. A. What price further mechanization? Pulpwood Ann. 1957: 100–102.

York, A. E. Keeping equipment on the job; maintenance program keeps logging machines out of shop. South. Lumberman 195(2441): 248–249. Dec. 15, 1957.

York, A. E. Maintenance program keeps logging machines on job. Noeast. Logger 6(1): 36–37, 57. July 1957.

314. Logging in Relation to Forestry

James, G. A. The effect of logging on discharge, temperature, and sedimentation of a salmon stream. U. S. Forest Serv. Alaska Forest Res. Cent. Tech. Notes. 39, 2 p. Mar. 1957.

Simmons, F. C. The impact of new methods and machinery on forest management. Noeast. Logger 6(1): 34–35, 54–56. July 1957.

Steinlin, H. J. Problems raised by timber extraction in mountain forests managed on the sustained yield principle. Food & Agr. Organ. United Nations. European Forestry Comn. FAO/EFC/LOG 65-A: 15–26. 1957.

32. Felling and Related Operations

Cobb, B. C. Bucking trees for top value. South. Lumberman 196(2442): 33–34. Jan. 1, 1958.

Cobb, B. C. Bucking sawtimber trees for top value in the Tennessee Valley. U. S. Tenn. Val. Authority. Div. Forestry Relat. Tech. Note 29, 10 p. Dec. 19[illegible].

McKenzie, W. M. Ripping logs with power chain saws. Austral. Timber J. 23(10): 10, 13, 111, 113. Nov. 1957.

Sharma, M. A., and Reddy, N. S. R's easier to work with the bark remover. Indian Farming 7(8): 18. Nov. 1957.

Smith, J. T. Home-grown felling policy. Timber Trades J. June 1957 (annu. spec. no.): 284–285.

Wyman, E. P. Throw away that wedge! South. Lumberman 196(2450): 54, 56. Mar. 1, 1958.

Wyman, E. P. A safer method of directional felling control with the chain saw. J. Forestry 55(11): 846. Nov. 1957.

33. Degree of Utilization and Waste

Pacific Logging Congress, Salvage Logging Panel. Pacific Logging Cong. Loggers Handb. 17(sect. III): 5–6. 1957. E. Hartley, moderator; members: R. Gould, R. Lindsay, C. Lewis, A. Ewing, and K. Hebard.

35. Work Efficiency

Baltzer, A. M. What the National Safety Council is doing. Noeast. Logger 7(3): 14–16, 40. Sept. 1958.

Canadian Pulp & Paper Association. Power saw accidents—causes and remedies; a panel discussion. Pulp & Paper Mag. Canada 59(7): 148–154, 156–157, 160, 162, 164. July 1958.
T. M. Pond, moderator; E. N. Denison, R. Ferragne, and F. W. Stevens, panel members.

Deabay, H. J. Safety training for loggers. South. Lumberman 197(2457): 38, 40. Aug. 15, 1958.

Jefferson, H. A safety program for the Northeastern Loggers' Association. Noeast. Logger 7(3): 18–20. Sept. 1958.

McCormack, G. R. Analysis of logging injuries. Pulp & Paper 32(7): 123–126. July 1958.

Netherlands Forest Labour Study Group. Time study of felling, lopping and barking of Pinus silvestris in the forestry in the Netherlands. Wageningen, Agr. U., Facul. Forestry, 1956. 9 p.

Northeastern Loggers' Congress. Greater safety on woods operations. Noeast. Logger 6(2): 30–33, 70–72. Aug. 1957.
Contents: The Lumberman's Safety Ass'n. of Ontario, by G. LaRochelle; Use of Slings and cables in the woods, by M. Quinn; Latest types safety clothing and equipment, by J. Rosenquist; Selling safety to woods workers, by C. R. Barr.

Reeves, E. H. Methods of attaining greater logging safety. Forest Prod J. 8(3): 28A–30A. Mar. 1958.

Stantial, S. Chain saw safety. Noeast. Logger 7(3): 17–18, 44. Sept. 1958.

Winchell, J. E. An insurance man's viewpoint. Noeast. Logger 7(3): 20–21. Sept. 1958.

36. Tools, Machines and Equipment Felling and Related Operations

Conroy, J. J. Developments leading toward a better power chain saw. Forest Prod. J. 7(10): 59A–60A. October 19[illegible].

Guerrero, F. A. Electric, gasoline, or diesel powered chain saws for logging, sawmill and plywood operations. Lumberman (Manila) 3(3): 13, 28. June/July 1957.

Hunt, B. H. Travelling case for power saws. Canad. Pulp & Paper Assoc. Woodlands Sect. Index 1706 (B-7-c), 3 p. July 1957.

Hunt, B. H. The pulp industry's outlook on power saw development. Timber Canada 18(11): 32, 34, 89. Nov. 1957.

Hurme, H. J. The design and development of a tree delimbing machine. Diss. Abs. 17(12): 2948. Dec. 1957.

Hutson, H. W. P., Zehetmayr, J. W. L., and Kirkland, C. P. The care and use of cross-cut saws. Q. J. Forestry 52(2): 91–106. Apr. 1958. Also in Gt. Brit. Forestry Com. J. 1956(25): 7–21.

McKenzie, W. M. The performance of scratch type power saw chains. Austral. Timber J. 23(4): 59–60, 62, 65, 67–68, 71, 73, 75–76, 107. May 1957.

Waddell, R. G. Winter hints for chain saw operators. Timber Canada 18(11): 37–39, 73. Nov. 1957.

37. Transport

371. Loading and Unloading

Morgan, J. I. Log loading practices and equipment discussed by boss logger. Pacific Logging Cong. Loggers Handb. 17: 27–28. 1957.

Mork, G. Multiple uses of new Bucyrus crane in logging operations. Pacific Logging Cong. Loggers Handb. 17: 16. 1957.

Scullion, A., and Scullion, M. Log rolling ramp. Canad. Pulp & Paper Assoc. Woodlands Sect. Index 1731(B-10), 1 p. Oct. 1957.

372. Land and Air Transport

Abol, I. P., Alabiev, V. I., and Rantsev, A. A. The haulage of timber by ground line and winch in the USSR. Food & Agr. Org. United Nations. European Forestry Comm. FAO/EFC/LOG 65-A: 54–74. 1957.

Biggar, J. C. Wheeled-tractor skidding and slashing of tree lengths. Pulp & Paper Mag. Canada 59(4): 229–230, 232, 234, 236, 238, 240, 242, 244, 246. Apr. 1958.

Carow, J., and Ruth, R. H. Mobile yarder shows promise in salvage. Timberman 58(10): 66–69, 104, 108. Sept. 20, 1957.

Cobb, B. C. Skidding with rubber-tired wheel tractors in the Tennessee Valley. U. S. Tenn. Val. Authority. Div. Forestry Relat. Tech. Note 26, 16 p. Jan. 1957.

Donatoni, A. Logging woodlots with a rubber tired tractor. Noeast. Logger 7(2): 43, 52. Aug. 1958.

Food and Agriculture Organization of the United Nations. Joint Committee on Forest Working Techniques and Training of Forest Workers. The handling and transport of timber in mountainous regions. Geneva, 1957. 94 p.

Gray, D. W. Tree-length wheeled skidding. Paper Indus. 39(6): 498–499. Sept. 1957. Also in Forest Prod. J. 7(10): 386–389. Oct. 1957.

Hachman, A. J. Harvesting woodlands with a light crawler tractor. Noeast. Logger 7(2): 24–25. Aug. 1958.

Keys, G. T. Report on the use of trucks in pulpwood logging in Eastern Canada. Canad. Pulp & Paper Assoc. Woodlands Sect. Index 1761(B-8-e), 8 p. n.d.

Lee, O. A. A new frontier in log hauling. Pacific Logging Cong. Loggers Handb. 17: 29–31. 1957.

Long, J. B. The Wagner "loggermobile". Noeast. Logger 8(2): 23–24. Aug. 1958.

Pratt, R. W. How to better log truck performance. II. Timberman 59(8): 37–38, 40–42, 44. July 1958.

Spiers, J. Mobile spars could be applied to N.Z. logging work. New Zeal. Timber J. & Forestry Rev. 3(12): 30–32. Aug. 1957.

Srivastava, B. P. A note on trials made with Koroleff's wire-skidding method and modifications thereof. Indian Forester 84(3): 131–134. Mar. 1958.

Willems, V. J. Haulin' greenheart (Ocotea rodioei). Timehri 1957(36): 36–39. Oct.

377. Equipment for Loading and Unloading, Skidding and Hauling

Bistrom, F. V. Development and operational problems of heavy duty logging trailers. Timberman 59(3): 33. Mar. 1958.

Guerrero, F. A. Wire rope for logging operations. Lumberman (Manila) 3(5): 23, 29. Oct./Nov. 1957.

Mattila, W. Whistle toots die out in Northwest forests. West. Conserv. J. 14(6): 48–49. Nov./Dec. 1957.

Pacific Logging Congress. What's new in logging. Pacific Logging Cong. Loggers Handb. 17: 32–34. 1957.
Cantilever log unloader, by A. J. Sandoz; Electric log stacker, by L. R. Robinson; Air powered chain saw, by J. L. Williams.

Spiers, J. The rubber-tyred tractor, a new logging tool. New Zeal. Timber J. & Forestry Rev. 3(11): 30–32. July 1957.

Spiers, J. The history and development of logging tractors. New Zeal. Timber J. & Forestry Rev. 3(9): 32–36. May 1957.

38. Forest Engineering

Berbano, S. A. Logging road construction. Lumberman (Manila) 3(3): 8–9, 13. June/July 1957.

Bjorkbom, J. C., and Trimble, G. R. Sow seed on logging roads to control erosion. Noeast. Logger 7(2, i.e. 1): 18–19, 36–37, 46. July 1958.

Griffes, R. B. Montana builds roads. West. Conserv. J. 15(1): 28, 54. Jan./Feb. 1958.

Huggard, E. R. Roads for economic timber extraction. Irish Forestry 14(2): 124–131. Winter 1957.

Huggard, E. R. Forest roads. Empire Forestry Rev. 36(3): 277–280. Sept. 1957.

Jones, H. How to locate logging roads. Timberman 59(6): 70–74. May 29, 1958.

Magnuson, W. G. Helping the public to get its money's worth. Amer. Forests 63(11): 40, 48–49. Nov. 1957.

McEachern, A. C. Keep road construction costs down. Timberman 59(8): 56, 58. July 1958.

Meyers, H. J., and Stern, L. J. Dust oil maintains logging road surfaces. Timberman 59(9): 60. Aug. 1958.

New Hampshire University. College of Agriculture. Extension Serv. New Hampshire guides for logging roads and skid trails. N. H. Agr. Col. Ext. Ext. Folder 35, 4 p. Jan. 1957.

Piironen, J. Truck haul roads speed up logging. Finn. Paper & Timber 8(7): 91. 1957.

Smith, F. J. Extraction road location and road clearance technique. Austral. Timber J. 23(7): 17, 19, 123. Aug. 1957.

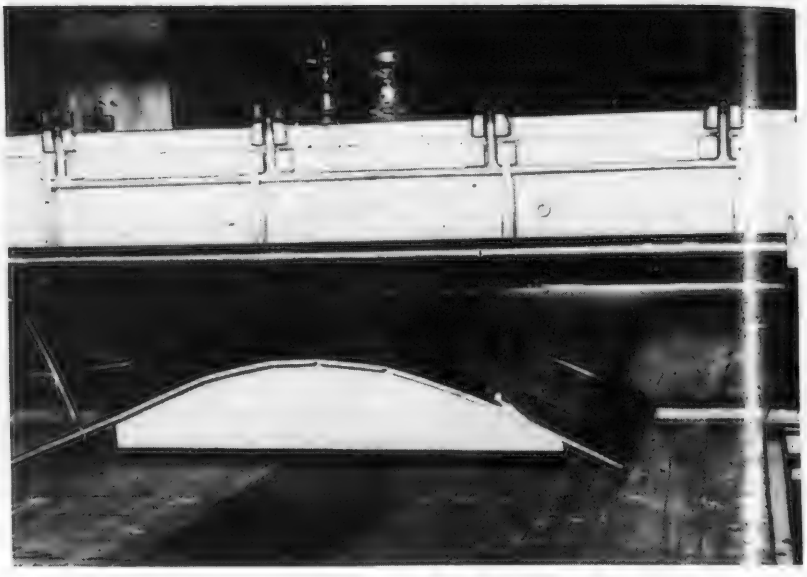
Wilfert, J. S. Report on potential use of mobile homes or trailers by the B. C. logging industry. Pulp & Paper Mag. 59(c, i.e. 3): 326, 328, 330. 1958.

1958 SUMMARY OF

Wood Finishing Developments

D. G. LUBECK[1]
Chairman, FPRS Wood Finishing Division

Automation increased markedly during 1958. Increased costs and more critical customers are forcing changes. New equipment, processes, and tests are described for both exterior and interior finishes.



Most finishing materials can be applied with a high-production flow-coating machine. Primary problem: limitations of contoured surfaces.

THE PROCESSES AND MATERIALS required to finish wood properly are being developed and improved at an ever-increasing rate. Concurrently, wood finishing in 1958 has shown a marked increase in automation. The industries that have adopted the mechanical approach to finishing are relatively new, and the products they produce are readily adaptable to mechanical handling. Particular reference is made to prefinished plywood where the volume is large, and the finished surface flat.

One might reasonably ask, why haven't the wood-using industries adopted finishing techniques equal to the techniques used in gluing, machining, and drying operations? The answer may be found in tradition. Finishing departments were the last to be penetrated by vendors, and so it follows that the finishing department will be the last department to reach an "age of enlightenment".

Many pressing factors, however, are hurrying the normal reluctance to change. Some of these are: cost of labor and material, taxes, increased production, awareness of the consumer's acceptance, and ability of suppliers of equipment and materials to meet customers' needs. The user of finishing materials is becoming aware that he must progress. He must, however, have a way to evaluate the benefits of one system over another, and must have the personnel who can devote the time to following the various projects.

The wood finishers must be continually aware of current developments, with emphasis on installations. The real problem, however, lies with encouraging young men to become proficient in wood finishing. The subject of interesting young men in wood technology has been receiving much publicity. The point that should be emphasized is—how can more of the men who have chosen wood technology be encouraged to follow wood finishing?

The developments in 1958 have reflected a general change of attitude with regard to the approach taken by the people who are involved with finishing wood. This attitude is reflected in many of the following ways:

Materials: In the past, the principal measure by which a material was selected was price per gallon. There were few other ways to determine the benefits of one material over another. Last year two pamphlets were published, which evaluated finishing materials. They were "The Control Testing of Finishing Materials", written by the Drexel Furniture Co. and published by the Southern Furniture Manufacturer's Assn., and the revision of the NAPV & L Assn.'s edition of "Control Testing Methods for Wood Finishes". Wood finishers are beginning to realize that the price per gallon is not the criterion for measurement. It is performance that counts.

The attention to performance is no doubt attributed more to new equipment on the market than any other single factor. Much of this equipment requires materials with balanced properties which in turn require more costly formulations. The increase in cost, however, is more than offset by performance.

[1] Contributors to this Review are: *Interior Finishes:* F. H. Thomas, L. Berg, W. E. Martin, G. Meyers, A. S. Kirsch, A. J. Albiston, W. I. Kyle, R. F. Wint, A. E. Gruhl, A. Lenaeus, and P. A. Blachman. *Exterior Finishes:* N. B. Garlock, W. A. Dost, R. A. Holcomb, and R. S. Taub. *Foreign Developments:* M. J. Merrick. *Processing Equipment:* H. C. Fornwall.

The Author: Don Lubeck holds a BS in wood technology from the University of Michigan. He works with finishing systems for the Hammond Organ. Co.

Equipment: It is apparent, at least at this time, that no one piece of equipment will produce optimum performance for all types of work. Pressure curtain flow coaters are gaining in popularity because of their speed, material milage and suitability for automation. They are limited, however, to flat work, and require special operations for the coating of edges. However, all these operations can be performed mechanically with a great labor and material saving factor.

For flat work, case goods and irregular shapes, improvements in spraying equipment are resulting in large savings over older methods.

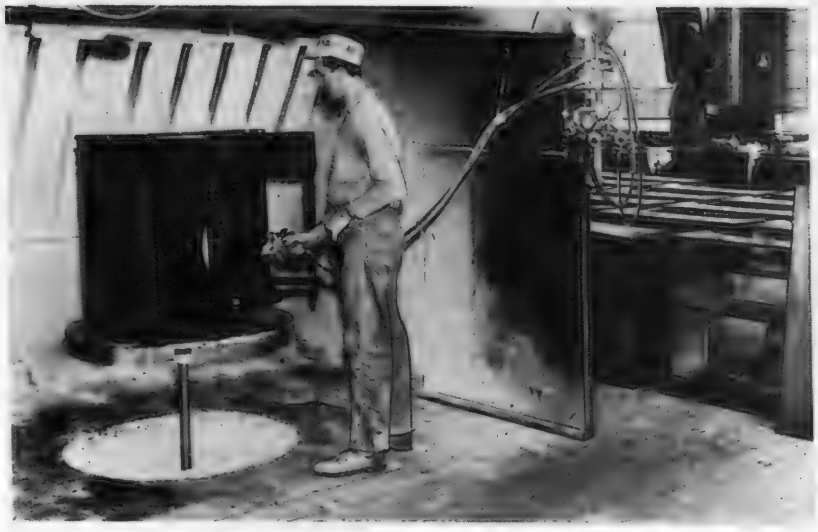
Airless spraying techniques, which are first beginning to take hold, are effecting great savings in labor and material. In addition, this process allows more control in application, results in tougher films, and substantially reduces subsequent processing problems.

Catalyst spraying guns that meter and mix the catalyst with the synthetics at the spray head have opened the way for more flexibility in material formation. This in turn will result in tougher, more solvent-resistant films that are easier to apply and require less processing because of build and flow.

Automatic spraying of finishes on wood has found some application, but to date, the use of this method of application has been restricted to those applications that have large volume output. The benefits of automatic spraying are too tempting to preclude its use on a larger scale in wood finishing.

Construction Changes: In the past, little attention was paid to finishing problems relative to construction. Casegoods for example, are designed and consrtucted as tradition has dictated and shoved into the finishing room for processing.

As a result of improved processing methods, more attention will now be given to finishing good work more economically. This, in turn, suggests multiple finishing operations, that is, pressure-curtain flow coating those parts suited to this method; spraying the parts that can best be handled by spraying, and flow coating or dipping the parts that can best be coated by this method. All these processes will eventually be performed in the same finishing room simultaneously.



Grayco direct-supply spray unit used at Hammond Organ Co.

Wood Preparation: Shorter finishing cycles illustrate the need for proper wood preparation. When an article to be finished was in a finishing room for three or four days, the normal time lag allowed for an equalization of moisture and stress factors, and included time for added operations to compensate for poorly processed wood.

Finishing cycles that were once measured in days, and now in hours, will soon be measured in minutes. A key factor to this automation will be proper wood preparation. Veneer and cabinet room foremen will spend more time in the finishing rooms to study the results of their work.

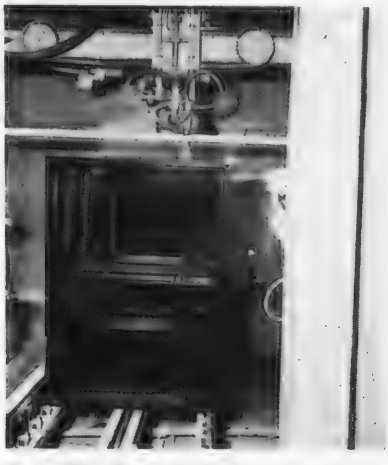
Some work has been done on wood stabilizers. It is entirely possible that in a few years the first finishing operation, before or after sanding, will be the application of a stabilizer that will normalize the inherent difference in wood and control dimensional changes.

Finishing Controls: The pamphlets mentioned previously in the section on Materials describe methods by which materials can be checked on a control basis. Equally important are the controls that must be applied to processing schedules and methods of application. Prescribed film builds must be maintained, which will regulate air and fluid pressures, gun settings and speed of application. Processing times and temperatures will have to be closely maintained. As evidenced in this past year, the demand for methods to train production personnel will increase. Many of the methods of training personnel are available. They need to be organized, published, and put into practice.

Finishing Problems: A survey conducted by the National Association of Furniture Manufacturers and published

Nordson airless spraying equipment at Carr Mfg. Co.

Grayco truck-mounted airless Hydra-Spray unit.



DeVilbiss automatic pressurized dry-type spray booth.

in 1956, has adequately described many of the problems facing the user of finishing materials.

It should be pointed out that the problems listed in the 1956 survey are still the problems of today; and the problems listed, in general, apply to all wood finishers. The results of the survey, as made by the National Association of Furniture Manufacturers is as follows:

A—In response to the question, "What are the three most important finishing problems confronting you today", manufacturers responded as follows:

1. *Color control*—More manufacturers stressed this problem than all others combined. Need for developing uniformity of finish from one production cutting to another was stressed.
2. *Keeping up to date with color and finishing trends.* This ran second in importance of manufacturers' three most important problems.
3. *Training and supervision of finishing personnel.* This was definitely in third place in manufacturers' problems.
4. *Need for better technical information on wood preparation* (sanding, sealing, filling, and so forth) rated quite high as a problem to manufacturers.
5. *Reducing cost of materials and time of finishing operation* was stressed by many manufacturers (less rubbing —fewer operations, and so forth).
6. *Developing more durable finishes* is an important problem.
7. Need for better information on controlling dirt and dust.
8. Develop a mechanical means to eliminate hand rubbing.
9. Fading of finishes rated as an important problem.
10. Other problems cited include:
    - (a) Temperature and moisture control
    - (b) Adhesion
    - (c) Correct spraying procedure
    - (d) Uniform quality of materials
    - (e) Discoloration of lighter finishes
    - (f) Grain raising
    - (g) Touch up materials
    - (h) Incompetent field men
    - (i) Variance in finishing standards and specifications
    - (j) Toners that do not leave a painted effect
    - (k) Finish becoming soft when exposed to perspiring skin
    - (l) Pinholes in mahogany
    - (m) Excessive shrinkage
    - (n) Crazing of lacquers
    - (o) Lack of technical information
    - (p) Lack of information on new product developments and techniques
    - (q) "Process Engineering" of finishes
    - (r) Need clear protective finish for brass and copper plated parts
    - (s) "Printing" problems on newly finished surfaces during hot spells.
    - (t) Temperature and moisture control
    - (u) Develop stains to hold color

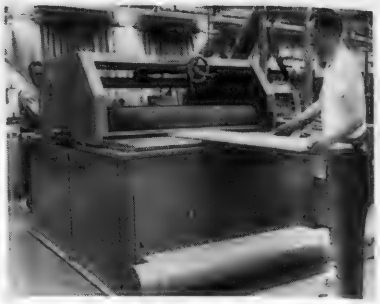
B—Ninety-five per cent of the manufacturers expressed an interest in response to the question concerning the value of a Finishing Handbook kept up to date with periodic supplements.

C—In answer to the question as to whether or not they would be interested in sending someone from their plant to a finishing clinic, 77 per cent of the manufacturers responding indicated such an interest.

D—In answer to the question, "What can our two industries (furniture and finishing material suppliers) do either jointly or individually to assist with these problems"? the following recommendations and suggestions were received:

1. More joint research by both industries on all problems.
2. Experiment with mechanical ways for rubbing.
3. Develop color standards and way to check color of finish electronically or photographically.
4. Reduce costs by developing more simplified ways to finish.
5. Finish industry develop a program for in-the-plant training of furniture manufacturers' personnel.
6. Improve quality control at finish manufacturers' level.
7. Do special research on sanding techniques.
8. Finish manufacturer educates furniture manufacturer on importance of surface preparation.
9. Develop conductive coating to allow application of electrostatic spraying of wood.
10. Devise finishing material with water repellent factor (silicone?)
11. Develop one best method to make toner finishes.
12. Set up graphs of performance rate versus cost of finish.
13. Better service in the field—technical field men, not salesmen.
14. Research on touch up materials.
15. Set up an association Laboratory with impartial experts to advise the furniture manufacturer.
16. Develop easy application of varnish finishes required by Government Quartermaster or induce Quartermaster to accept a different finish.
17. Develop a basic material that will let furniture set unfinished yet have stain to avoid adhesion.

Mattison Pinch Roll single wide-belt sander, with contact roll for sizing.



Single wide-belt flat-bed sander by J. M. Nash, with platen or contact roll for sizing.

Processing Equipment and Techniques

Sanding: "One of the most important machinery advances in the woodworking industries has been the development of the wide-belt sanding machines. These sanders have improved sanding in the following ways:

1. Faster sanding speeds, two to four times faster than any other method. 2. Cooler cutting means less loading and longer grit life. 3. Smaller grit sequences.

"The new developments and refinements by abrasive manufacturers in recent years have been: papers with stronger tensile strength, synthetic abrasive almost diamond hard and backings, both paper and cloth that offer greatly increasing strength and flexibility, a deterrent to premature breakdown of the backing under severe work-pressure conditions."[2]

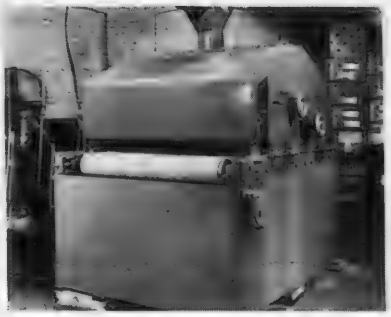
A machine has been introduced to sand seal on flat stock.[3] Admittedly there are several prerequisites to such an operation, such as properly manufactured stock free of warp, twist, and sunken joints.

While new sanding machines and techniques cannot be used without some qualifications, the important feature is that the manufacturers of abrasives and sanding equipment are leading the way towards proper preparation of wood for finishing. The fact that the use of high-production equipment is limited because of present production practices points out a feature that wood finishers have long recognized, and that is, if wood is to be finished properly, it must be properly prepared for finishing.

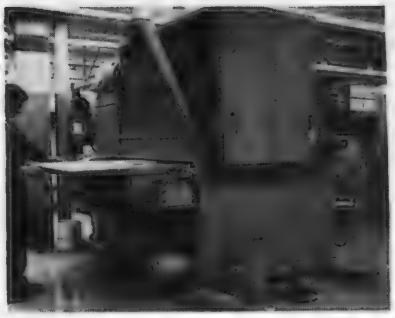
Pressure-Curtain Coaters: Pressure-curtain coaters, or flow coaters, are gaining ever-increasing popularity. A summary of the Steinemann coater appears in the October, 1958 issue of the JOURNAL. A description of the application is presented with pictures of the equipment. An article appearing in the December, 1958 issue of WOOD & WOOD PRODUCTS, describes an in-production use of a flow coater. A step by step description is made of a convevorized finishing line for kitchen cabinets.

[2] Bennett, Harvey. The Wide Belt Sanding Machine in Woodworking. April, 1957 FPRS Joint Wood Industries Conference.
[3] Woodworking Digest, January 1957

Sherrill Speed Feed single wide-belt sander, with contact roll for sizing. All sander photos courtesy Behr Manning.



Single wide-belt Indiana sander by Union Tool, with platen or contact roll for sizing.



Yates–American multiple wide-belt Satin Finisher, with combination roll and platen for complete grit sequence in a single pass.

Coating machines such as the Burkle, Fritz, Hymmenia and Steinemann were first introduced in this country only recently although they have been used for the past several years in Europe, particularly West Germany. This is a pouring type of application, sometimes referred to as "veil coating", that can be used for applying lacquers, varnishes, enamels, paints, waxes, plastisols, organosols, and most other finishing materials to flat surfaces or surfaces with only a slight contour. The adaptability of the two-headed machine to applying two-component polyesters makes possible the immediate adoption of this very desirable finish on a commercial scale. One large manufacturer of wood cabinets reports the following on his experimental use of lacquer with this machine:

1. We find that there are no tight limits on the viscosity of the lacquer for veil coating. We have veiled lacquer in the range of 30 to 50 seconds on the Ford #4 Cup; however we feel that lacquers of considerably higher viscosity, which are in the range of 100 to 120 seconds, could be veiled satisfactorily.

2. The material savings of veiling versus spraying are noteworthy. The efficiency of a gallon of lacquer by veiling is approximately 90%; whereas, by spray this is generally from 50% to 60%. This efficiency is figured on the solids by volume of the material, which enables one to calculate the theoretical coverage or surface area for a 1.0 mil film thickness.

3. There is some evaporation loss of the solvents in the veiling operation. A good lacquer thinner is recommended; that is, one that does not evaporate too fast. Approximately five gallons of thinner are added to the lacquer through a normal eight-hour day.

4. The veiling machine is a high-production machine, since approximately 400 panels can be passed through the machine in one hour with a three-man crew; that is, one feeding and two tailing the machine. This estimate is based on panels of approximately three square feet in area and ¾" thick.

5. The flow out of the lacquer coats is good. There is virtually no orange peel noticeable in veiling.

6. The moulding on a panel, if it is to be coated, is a limiting factor. A straight moulding with square corners can be coated, but intricate "design" mouldings or large-radius corners will not be completely coated by this machine. Since the panel is fed into the veil with two moulding edges making a 45° angle to the veil, only the front two moulding edges are coated for each coat applied. The veil must be adjusted so that runs, sags, and heavy edges do not form on the moulding. Since this is important on our product, we can obtain only 0.85 mil film thickness per coat with a 27.5% solids by weight lacquer. However, if high solids and viscosity materials are used, it is felt that a film thickness of 1.0 mil or more could be obtained per coat.

Variation of the Steinemann machine with a tilted conveyor belt for coating profiles.

Flow Coating: Flow coating, a process generally associated with the metal industry, has been receiving more attention with respect to its application to wood. It is distinguished from pressure-curtain in that it consists of a chamber with several nozzles, similar to garden hoses. Material is pumped through the nozzles and literally splashes over the work passing through the chamber. The pressure curtain is a carefully controlled vertical sheet of finishing material.

Any object that can be dipped can be flow-coated with improved results. With increasing labor and material cost, processes that lend themselves to controlled application, 95% material usage and automation will certainly draw attention. Where pressure-curtains are used for flat work, flow coaters can be used for complicated and irregular shapes.

Steam Spray: Steam spray, the method of application that uses superheated dry steam in place of compressed air as a propellant to carry the finishing material from the gun to the work, continues to be of interest. While this method of spraying has gained limited acceptance in wood finishing, the factor to keep in mind is that materials are changing and that this method may prove of greater interest with future developments.

Hot Spray: Hot spray (140°160° F) has become well established in the applications of lacquers and sealers. This has become an important step in wood finishing, because it has drawn attention to how technology can aid the user of finishing materials.

The use of hot spray is producing top-coat films with more integrity, since the use of heat allows for more latitude in formulation. It has produced savings in material and labor, and will continue to offer these advantages.

Warm spray (100°–135° F) has found wider acceptance than hot spray, primarily because materials sprayed cold can be sprayeed warm without changes in formulation. Of the many advantages of warm spray, such as increase in build, material savings, flow-out, and so forth, the principal advantage is that of uniformity. A given material can always be expected to produce uniform results if the viscosity is controlled. Prior to paint heaters, cold material was always a source of trouble.

"Memory Timer" units on this 8-arm Binks reciprocating spray machine automatically control each spray gun for maximum efficiency.

The "do's and don'ts" in using and maintaining spray painting equipment are stressed in Binks' free 5-day school.

Airless Spray: Airless spray, the application of finishing material by the use of high pressure in place of compressed air, has definitely established itself as an application technique. While this technique has been primarily used with lacquer, some companies successfully spray stain, washcoat, filler, and sealers.

Heat is most generally used with airless spraying. The temperature used ranges from 160° F to 180° F depending on the material. There are some applications where no heat is used with the airless spray.

The advantages claimed, and substantiated in many cases where studies were made, are as follows:

1. Savings in compressed air.
2. Heated materials reach the wood at a higher temperature, since there is no compressed air to cool the fluid.
3. Less bounce-back and dry spray.
4. Exhaust air can be reduced, which reduces heat losses.
5. Higher gloss, smoother and tougher films.
6. Substantial material savings.

Infra-Red Drying: The all-out effort to reduce cost has focused more attention on methods that will accelerate drying. Infra-red has been used for drying finishes on metal for many years, but the application of this principal to the wood industry has been limited.

It is generally thought that the interest in infra-red drying will gain in momentum because developments in other fields such as hot and airless spray are resulting in finishing materials that are more suitable for this type of drying than the conventional cold lacquers.

Electrostatic Spraying: Electrostatic spraying is another process of paint application that has long been associated with the metal industry. There have been some attempts to use this process in wood. The problem with wood is that it is difficult to produce a field of attraction. The use of graphite in fillers or undercoats has produced some success. It is possible that, as materials change, and equipment and techniques improve, electrostatic spraying will be used to apply finishing materials to wood.

Spraying Techniques: An interesting article "Efficient Spray Fnishing" by J. F. McCaslin, appears in the October, 1958 issue of the Journal. This article describes the controls that are necessary for efficient finishing room operations.

Shorter finishing cycles and increased production have resulted in many problems that originate in application. Proper spraying techniques are not a one-shot operation, but require the continual training of spray operators.

Exterior Finishes

In the area of exterior finishes for wood, there are rarely many spectacular deevlopments. Rather, trends announced one year are frequently better developed the following year. Formulation of exterior finishes requires considerable time and testing before results are conclusive.

More blister and stain proof paints are continually put on the market, and when they contain no active pigments, the problem of mold control becomes serious. Considerable investigation of the different molds that appear on such paints has been announced. In this connection, active efforts are being made to develop additives that will prevent mold growth.

The alkyd vehicle blister- and stain-resistant paints are reported to have blister resistance even when applied over repaints where the blister or moisture condition is not severe. Also if the alkyd paint is used as a first coat, good blister resistance will result when oil paints or emulsion paints are used as repaints. If the moisture condition is severe, it is still necessary to remove all vestiges of old paint before repainting with alkyd paints. Isophthalic alkyds have been used in house paints to some extent. They have faster dry and higher gloss than oil paints, but they lack the mold resistance of paints with active pigments.

It has been expected that emulsion paints with wide variations in pigmentation have given satisfactory results with regards to chalking, dirt collection, and protection. Also, a device to promote better adhesion of emulsion paints to chalky surfaces was announced. This involved the addition of 10 to 25 per cent toluene or xylene to the vehicle. It was claimed that no degradation of a polyvinyl acetate paint resulted from such additions.

The use of clear finishes on redwood or red cedar continues without a truly satisfactory coating being available. It was announced that alkyds give good durability, but they are likely to make repainting difficult. The California Redwood Association suggests the use of only a water-repellent solution repeated at frequent intervals. This presents no repaint problem, and it keeps the wood from weathering. Provided a pigmented coating of the color of the wood is satisfactory, much longer intervals between repainting are possible.

Attention was called to the possibility of unwarranted claims of poor paint performance on mill primed lumber. This term may describe a water-repellent treatment or a very thin coat of paint. If at least two full coats

are not applied to mill-primed lumber, premature degregation may result. It has been suggested that the paint used in mill-priming might not not be compatible with the field coat, so that mill-priming is not encouraged.

Test Methods

Smoothness: A constant problem that harasses the wood finisher is inconsistent surface preparation. A paper presented in Madison at the National Convention, and appearing in the October, 1958 issue of the FOREST PRODUCTS JOURNAL, describes several methods for evaluating surface-smoothness. The paper, "Measuring Smoothness of Wood" by A. Elmendorf and T. W. Vaughan describes various methods that were studied to determine the relative smoothness of a special sanding technique (micro-sealing) to more conventional methods with abrasive paper.

Exposure of Natural Finishes: A Wood Award entry titled "Evaluating Exterior Natural Finishes", by J. M. Burger, appears in the October, 1958 issue of the JOURNAL. "This paper describes an evaluation of 18 types of proprietary finishes applied to Philippine Mahogany. After exposure in a weatherometer for 865 hours, the relative durability was determined by visual inspection. Measurements of weight change, gloss, hardness, surface roughness, wetting angle of a water droplet, and tri-stimulus color difference made during weathering were then analyzed graphically to determine whether any quantitative techniques would establish durability classes in agreement with visual classifications."

Print Test: A test has been devised by the Furniture Development Council[4] to rate the print resistance of lacquers. The test is designed to give a comparative rating. Briefly, the procedure is as follows:

1. A series of 16 circles are stamped on the backside of a clear glass slate.
2. Lacquer is poured on the glass and a wet-film applicator drawn down the glass to produce a wet film of 0.004 inch.
3. Fifteen minutes after application of the film, a nylon fabric is placed over one of the circles and a 4 lb. weight is placed on the fabric through a load applicator for 30 seconds.
4. The test is repeated at 5 minute intervals over a period of 120 minutes.
5. If printing is applied after 2 hours, a lighter weight is used.

[4] Furniture Development Council, 2/4 Dalmen Ave., London, N. 7, England.

Clear epoxy resin sprayed on wood (inset) provides extreme chemical resistance, excellent adhesion, and low maintenance cost, according to Union Carbide Plastics Co.

6. A special viewing cabinet is described for controlled observation.

Bloom Test: "Blooming", as distinct from "blushing or chilling", is understood to refer to the blue or white haze that may form on a finish some weeks or months after preparation, whereas "blushing" occurs from an entirely different cause during the spraying and drying of lacquers.

The test is of a comparative type, and is performed under controlled conditions.

Briefly, the test is performed as follows:

1. An 0.004-inch wet film is deposited on 4 Vitrolite plates by means of a wet-film applicator and dryed 24 hours.
2. Three Vitrolite plates are each placed in a glass tank. In one tank is placed a boiling tube of 5 ml. of ammonia solution; in another tank a Petri-dish containing fuming sulphuric acid. Nothing is added to the third tank.
3. Lids are placed tightly on the tanks, and the tanks are placed under a fluorescent tube for 22 hours.
4. The Vitrolite plates are removed and breath is exhaled six times over each panel.
5. A 45° glossmeter is used to rate the bloom. The fourth plate, which was not placed in a tank, acts as a control.

[5] Furniture Development Council, ibid.

Wear Test For Nitrocellulose Lacquers:[6] Purpose of Test. This test has been developed to provide a means of assessing the tendency of a lacquer to wear away in practice when it is rubbed with soft articles such as dusters, clothes, the human hands, and so forth. Since the wear of lacquer on furniture normally occurs slowly and some time after the furniture has left the finishing shop, it is obvious that a lacquer to be tested for wear must be dried to a condition comparable with that obtained after "aging" in practice. For this purpose, drying of the lacquer for 1 day at 60°C has been in the main found adequate. Longer drying of the lacquer at this temperature (up to 7 days) does not appear to produce any variation in the results obtained, other than the normal variation resulting from duplicate tests.

A modified Carpet Abrasion Machine of the Wood Industries Research Association is used for the test. The 4 by 4 inch lacquered and dried plate is held in an inverted position in a rotating head. During rotation, the plate rests on an abrading head of 1¼ inch diameter, which is covered with nylon fabric, the abrading material. The abrading head also rotates and with the same angular velocity as the lacquered plate. Because of this fact, and since the two centers of rotation are not coincident, at any point along a line joining the two centers the relative linear velocity of lacquered plate and abrading nylon is constant. This fact results in quite uniform wearing of the lacquer. Loss of weight of a lacquer submitted to wear in the machine is measured.

[6] Furniture Development Council.

Fine Scratch Test For Glossy Nitrocellulose Lacquers:[7] This test has been developed to show to what extent a glossy lacquer is liable to show permanent fine lines or marks when scratched. This damage by scratching is liable to occur immediately after the finishing process is completed and accordingly, as distinct from the procedure adopted in the F. D. C. Wear Test, drying of the test panels is carried out for 1 days at 25°C. The test is not intended for matt lacquers.

A blanket is used to produce the scratching of the lacquer, the fine scratches obtained being produced by the rough disorderly surface of the wool. The blanket is well suited for the purpose, producing more scratching than most other common materials; also the results obtained with a blanket have been found to be more reproducible than those with other possible materials or substances. Another factor of importance arises from the fact that fine scratches are produced and the result of the test is not influenced by the adhesion of a lacquer to its substrate.

In the test, a piece of blanket is fixed to a rotating metal head resting on the lacquered plate. Glossmeter readings are taken of scratched and unscratched areas of the lacquer.

Foreign Developments

In general, the past year has been one of consolidation and selection of new materials and processes that have been developed in recent years. It is probably true to say that no new material or process has appeared, but that some possible clear lines of future development are beginning to emerge from the tangle of claims and counterclaims that have arisen in the recent past.

Materials: So far as furniture finishes are concerned, the probable progress of polyester finishes has become more clear. It is now apparent that most of the less responsible statements made about these materials, are not being justified under production conditions, in so far as furniture is concerned. The unsaturated polyesters are, however, finding their place, particularly in the field of radio and television cabinets. The hard, high-glass finish appears acceptable to public taste, and the article may be designed fairly easily for rapid burnishing after spraying. A sizeable proportion, possibly approaching half, of the radio cabinets produced in England and Germany are now being finished by this process.

The relative merits of the wax-containing versus the wax-free polyesters are still somewhat obscure. Various developments have taken place in the past year to assist in the catalyst application difficulty with polyesters, and a system has now been developed for precoating with catalyst before applying the main film of polyester resin plus accelerator. This makes it possible to use polyester in a single-headed curtain coating machine (of which see more below) whereas double-headed machines were previously necessary. It also renders the spraying of polyesters easier, since normal spray equipment may now be used. It is apparent in this field that over the past year there have been a number of developments and advances to make production easier. In the long run, however, although polyesters give a somewhat harder and glossier finish than the medium nitrocelluloses, they still come out slightly more expensive, quite apart from the limitations on design that are imposed by the material.

One indirect effect of the great interest in unsaturated polyesters has been to stimulate interest in other synthetics. Traditional nitrocellulose users are now also becoming aware to the possibilities of using the somewhat neglected cold-catalyzed urea finishes and similar synthetics. It will be interesting to see to what extent the wide publicity given to polyester will increase the use of these other materials.

The polyesters cross-linked with diisocyanates, more commonly known as polyurethanes, do not yet appear to have touched the furniture field, and, on the face of it, it does not appear that they are likely to do so in the foreseeable future. For exterior varnishes are becoming increasingly used, particularly in marine work, where the use of such avarnish on the "Sceptre" has aroused considerable interest amongst yacht and boat builders.

In more traditional fields, nitrocellulose lacquers appear to have held their own very well, and in many cases furniture is being produced of burnished nitrocellulose which is hardly distinguishable in appearance from polyester. Similarly, some furniture manufacturers, to ease their design problem, are finishing car cases with nitrocellulose and doors only with polyester.

In the nitrocellulose field the use of butyrate instead of nitrate for water white lacquers appears to be on the increase. This development, however, does not, affect the problem of colour change in the wood, naturally finished furniture. There still seems to be no sign of a general solution. The use of ultra-violet absorbers, although helpful in the case of some woods, gives disappointing results when used on the common furniture woods such as walnut and mahogany. Research is, however, going on in various laboratories from both the fundamental wood chemistry point of view, and on the more applied aspects, in an attempt to find a solution to this problem.

So far as exterior finishes are concerned, progress during the year has been almost entirely in evaluation and field testing of various exterior varnishes. The increasing use of timber as an external cladding material (previously rather uncommon in Europe) in modern architecture, has led to a much greater interest in the durability of external wood finishes. Field tests carried out by various European laboratories have, however, shown rather disappointing results in the durability of various synthetic varnishes. Some epoxy resin varnishes, for instance, notwithstanding their excellent chemical resistance, have in general, shown rather surprisingly poor resistance to weathering. The picture is, however, still very confused, and in particular, the dangers of praising or condemning one particular broad group of varnishes on the basis of test results on perhaps only one or two examples in that group cannot be over-emphasized.

Application: The year has seen the rapid increase in the use of the curtain coating machines which appeared some three or four years ago. There are now four machines commercially available in Europe, all possessing very similar operating characteristics. Single-headed curtain coaters are being used quite successfully with nitrocellulose, and double-headed curtain coaters, on a smaller scale, are being used for polyester. With the usual ingenuity of furniture manufacturers and woodworkers generally, double-headed curtain coaters are also being used to spread nitrocellulose. Increased film thickness and productivity are obtained in this way, and single-headed machines are being used to spread polyester, a development made possible by the separate application catalyst for these materials.

There seems little doubt that the interest in these machines will increase considerably. One of the main difficulties is to get enough work to put through them to justify the capital expenditure. This problem is, of course, particularly acute in the smaller firms. It is essential, of course, that these machines finish material in the flat, which usually means before assembly so far as furniture is concerned. For traditional European furniture, which includes a large number of wardrobes, this necessitates in most cases the complete redesign of the article and the

[7] Furniture Development Council—ibid.

Four-step rubbing procedure from Johnson's Wax: (1) initial sanding with 320 or 360 wet and dry paper and wax rubbing lubricant; (2) felt-block operation with rubbing lubricant and 3 or 4-F pumice; (3) cloth rub with residual pumice and lubricant left on surface; and (4) final clean-up operation with either cream wax emulsion or nut brown wax.

adoption of new methods of construction and assembly. It would appear possible, then, that we may expect some changes in the design of furniture, particularly in the medium and lower priced furniture.

Other methods of applications such as airless spraying, catalyst spray guns, steam spraying, electrostatic spraying, and so forth, still do not appear to have made any great inroads, in the furniture industry. It is still too early to judge what the future of these various methods will be.

Research: Current research in Europe is being carried out mainly by the larger manufacturers of wood finishing materials. The results of their work appear from time to time in the various European wood finishing journals. So far as the non-commercial laboratories are concerned, field tests on exterior varnishes are being carried out by a number of people, including the Timber Development Association, London, and the Centre Technique de Bois, Paris. Some work on faults in wood finishes, such as the causes of checking and so forth, are also being carried out at Prufstelle für Sperrholz, andere Holzerzeugnisse und Holzleime, Karlsruhe. Work is also going on at other research laboratories too numerous to mention, but it is probable that the three mentioned above are the most important centers for work mentioned.

The research program of the Furniture Development Council is concerned with:

1. *Spraying.* A theoretical analysis of the atomization process as it occurs in the normal spray gun is being done. This investigation may be sub-divided into two parts: (a) the relation between droplet size distribution and spraying conditions; and (b) the distribution of air velocities and consequent lacquer distribution over the spray cone. At the same time, work of an experimental nature is being carried out to obtain more direct information on various spray guns. This work is conveniently sub-divided into: (a) direct measurement of the loss of lacquer through "fog" and "bounce" (but not overspray) in spraying large flat areas under various operating conditions. (b) The distribution of the lacquer over the spray cone under various operating conditions. It has already been found that small differences in spray-gun design can have considerable effect.

2. *Evaluation of Lacquers.* Research into the development of quantitative, objective and repeatable test methods of lacquers has been made possible by a grant from Great Universal Stores, a large British furniture retailing group. The idea behind the development of these tests is to provide information for the buyer of lacquer, so that he can choose the best one for his particular purpose. It is well known that all lacquer formulations contain compromises, since one particular property can often only be obtained at the expense of another. It is the purpose of the test methods to attempt to separate and measure these properties. So far test methods have been developed for:–

1. Printing.
2. Bloom resistance (a very important property in the United Kingdom in view of its climate).
3. Fine scratch resistance.
4. Wear resistance.

Work is in progress on the development of tests for cold check resistance and for heat resistance. Further tests will be devised as the program proceeds.

3. *Other Work.* Other miscellaneous projects include investigations into means of preventing color changes in wood; the evaluation of the surface roughness of wood, in an attempt to speed up sanding operations; the basic causes of various finishing faults such as checking, pin-holding, and so forth, and various ad-hoc investigations for individual manufacturers.

Interior Finishes

Wood Bleaching: Recent trends in wood bleaching do not involve new materials, but rather some modification of older materials and methods. This is guided by a better understanding of the bleaching reaction and its after effects.

Hydrogen peroxide—sodium hydroxide bleaches still have widest acceptance, but are now frequently used in more dilute form. An average diluted mixture is 1 part #1 Alkaline component, 2 parts 35% hydrogen peroxide, 3 parts water. More than two applications are seldom used. The general idea is to use the minimum amount of bleaching chemicals, especially the alkali component, and to avoid bleaching beyond the requirements of the final color desired. Moderate bleaching produces better wood value and minimizes possible after effects of bleach.

The bleaching effect at room temperature is substantially complete in not over 30 minutes. It is visibly increased by a short heating interval of about 15 minutes at temperature 130–140° (allowing 5 to 10 minutes penetration or diffusion time before heating). It is still desirable to wash after bleaching. Washing with plain water appears as effective as neutralizing with dilute acids. The stronger the bleach used, the more thorough should be the washing.

For orthodox finishing systems, thorough drying after washing is essential. Overnight dry at room temperature is usually sufficient. Oven drying at schedules ranging from 45 minutes at 140° to 90 minutes at 125° is more positive and reliable under varying atmospheric conditions.

The ammonium bicarbonate-hydrogen peroxide method suggested some

time ago as a means of avoiding alkaline bleach residues has not gained general acceptance. It has been observed in several cases to aggravate after-yellowing of bleached wood.

For moderate bleaching, there has been some revival of using sodium bisulphite, especially when followed by water based emulsion type washcoats or toners. The re-wetting with emulsion intesifies the bleaching action of bisulphite. This method permits washcoating or toning on the wet bleached surface without intermediate washing or complete drying. High concentrations of bishulphite should be avoided; it should probably not exceed 8 ounces per gallon of water.

Washcoat sealers generally favored after any bleaching method are the vinyl sealers and acrylic emulsions. Both show good resistance to subsequent damage by residues of bleaching chemicals.

Kitchen Cabinet Finishing: The advent of the building boom after World War II gave rise to a new, growing industry. Architects and designers, yielding to the trend toward "living in the kitchen", became more style and color conscious coupled with greater efficiency of lay-out. The vast appliance utilities were subsequently made available in a host of pastel colors. The introduction of color into the American kitchen constituted the basis of the revolution and destroyed forever the outworn concept that a kitchen must be traditionally white. The cabinet industry, in close alliance with the paint industry, followed this trend closely to provide pastel enamel finishes whose colors match those of the appliances or complemented them with the result that the kitchen took on a warm, cheery inviting glow in the "new look" of American homes. The fashion in enameled kitchens continued thru the late '40's and into the early '50's when again a style change took shape. This latter trend was toward clear wood finishes, in a variety of colors. This fashion trend has grown in popularity to the extent that today over 80 per cent of kitchens produced are of the clear wood finish type.

Initially, the clear wood finish colors were attained with conventional acid analine NGR stains. This type of coloring was, however, highly unsatisfactory due to relatively poor light stability. The meta-chrome azo dyes were then substituted for the NGR colors with considerable improvement in lightfastness and the use of this class of dyestuff has grown markedly in the last 2 years. Concurrently, with the advance of dyetype coloring matter, the pigmented wiping stain was also employed. This type of decorating media left much to be desired in that color was not of a sufficiently uniform calibre to be accepted to the market and the additional labor cost in application was prohibitive.

To offset these objections, wood finish materials manufacturers perfected the pigmented, spray non-wipe type stains which tend to uniform the wood and at the same time accentuate the grain. This type of coloring found immediate acceptance nationally and continues to grow in popularity. Within the last 2 years, still another color concept has been introduced and is beginning to gain wide acceptance. This latter style is known as the "suspended" finish. The coloring matter (dye and pigment) is introduced between the sealer and the finish coat. The effect is toward clear wood with the grain subdued rather than accentuated. This coloring system is gaining popularity at a slower pace than did the other systems but should continue to grow based on the beautiful compromise color effects it makes possible.

Trends in finishing materials in the kitchen cabinet industry are toward the catalyzed urea, alkyd finish. The swing to conversion varnish is dictated by superior fullness, mar-resistance and solvent resistance at lower cost per square foot. Currently, kitchen cabinets are being finished in 5 basic systems. The lowest cost units are decorated with a tinted lacquer sealer followed by a clear semi-gloss conversion varnish. Somewhat better grade units employ a prestain low solids lacquer followed by lacquer sealer and conversion varnish. At the next quality level, the wood is stained with the special dye or pigmented stains, followed by vinyl type sealers and conversion finish coats. Top quality finishes are attained by presealing the wood with a vinyl type sealer followed by a vinyl color coat and finished with conversion varnish. Again at the top quality level, the wood can be stained followed by 2 coats of specially formulated conversion varnish. All of these finishing systems lend themselves to both air dry and force dry cures.

New trends in finishing materials will be toward the use of conversion enamels to match the appliance finishes in gloss as well as color. These enamels will display considerably better films than conventional high gloss alkyd types enamels. The industry will also be testing polyester, modified epoxy and quite possibly polyurethane finishes in the coming year.

Survey of the Wood Household Furniture Industry:[8] A survey published by a large manufacturer of finish raw materials reported that the post war growth rate of household furniture was:

1. Less than half that of durable goods 2.2% versus 5.2%).

2. About equal to that of nondurable goods (2.2% versus 2.4%). Furniture purchases have lacked the steady growth of nondurable goods purchases and have shown less stability than nondurable goods.

Lacquer supplied about 80% of the finishes, synthetics 17% and varnishes 3%. Hot spray and warm spray moved in on conventional cold spray. Lacquer was chosen by most manufacturers because of its superior appearance, ease of repair, fast drying and ease of rubbing. Manufacturers asked for greater durability, better color retention, better rubbing qualities and improved clarity.

Finishes for Upholstered Furniture: One problem that came up this year was the softening of lacquer in contact with plastic upholstering materials. It was found that part of the effect was caused by the use of plastic which would soften lacquer when the two were in contact but also some of the effect was found to be due to a type of polyurethane foam used in the cushions. In this system the accelerating agent was a catalyst used in the polyurethane foam which migrated through the plastic upholstering and into the lacquer. The solution to this problem is to have a campatible system wherein there is no migration of chemicals that will cause a softening or other degrading effect on the lacquer. The entire system should be tested as a unit and when found satisfactory the sources of supply for each of the materials—that is, the lacquer finish, the plastic and the foam cushioning, should be kept to constant materials. A specially formulated lacquer is necessary for this application.

Non-yellowish, Non-staining Finishes: There were further development of lacquers based on acetate butyrate, which when properly modified gives wood lacquers that are non-staining and non-yellowing to a much greater degree than is possible with nitrocellulose base lacquers. Although the cost of these lacquers is significantly more than the equivalent nitrocellulose base lacquers, the improved color retention and resistance to staining should provide incentive for the purchase of these lacquers for use on blonde furniture and on desk tops where resistance to staining from rubber bases, such as on telephones, lamps, etc., is important.

[8] "The Wood Furniture Industry and Its Finishing Practices"—Hercules Powder Co.

Wood Seasoning Bibliography, 1956-7

S. B. Preston and D. E. Nelson
Chairman, Department of Wood Technology, and Wood Technology Student, University of Michigan, Ann Arbor

The Wood Drying Annual Review consists of a bibliography of leading literature in the field published largely in 1956–57. It is not intended to give complete coverage, but is limited to selected references that deal specifically with seasoning of lumber and veneer.

THE TITLES THAT FOLLOW were selected from 1) the United States Department of Agriculture Library, *Bibliography of Agriculture,* 1957 and 1958 (except December), 2) *Forestry Abstracts,* 1957 and 1958, and (3) *Russian Accessions,* 1957 and 1958 (except December). Information given for each reference, except for English translations of some titles, is limited to that in the source or sources in which it is listed. As a consequence, some inconstancies in citations exist.

For convenience, references are coded as F *(Forestry Abstracts),* A (U. S. Department of Agriculture, *Bibliography of Agriculture*) or R *(Russian Accessions).* Abstracts, some of which are very complete, are included with almost all references listed in *Forestry Abstracts.* Of the publications listed by the *Bibliography of Agriculture,* copies of periodical references may be purchased from the Department of Agriculture in photostatic form, and books and monographs are available on inter-library loan. Some references listed in *Russian Accessions* are similarly available from the Library of Congress.

1. Anon. F 1957. (Applications of electric heating in the wood industries.) Les Applications du Chauffage Electric Dans les Industries du Bois. Cah. Centre Tec. Bois No. 26.
2. Anon. R 1956. (Drying woods in liquids.) Zhil–Kom. Khoz. 6.(5):29.
3. Anon. F 1956–57. Effect of Air Speed on Drying Rate. Rep. For. Prod. Res. Bd., Lond. (12).
4. Anon. F 1956. Inspection and Maintenance of Lumber Dry Kilns and Equipment. U.S.F.S., For. Prod. Lab. Rpt. 1900–4, 48 pp.
5. Anon. F 1956–57. Kiln drying of red and white oak treated with urea crystals and a commercial salt with a corrosion inhibitor. Rep. S. E. For. Exp. Sta: 29.
6. Anon. F 1956. Kiln-Drying Schedules. Leafl. For. Prod. Res., Lond. No. 2 (rev.), 15 pp.
7. Anon. F 1957. Moisture measuring systems. For Prod. J. 7 (4): 29A.
8. Anon. F 1955–56. Radio-Frequency Drying. Rep. For. Prod. Res. Bd., Lond. (12–3).
9. Anon. F 1957. Redwood Seasoning Reports. California Redwood Assoc., San Francisco.
10. Anon. A 1956. Seasoning methods studied for incense cedar planks. Rep. Calif. For. Range Exp. Sta., 1955: pp. 33–4.
11. Anon. F 1956. Special Methods of Seasoning Wood: Boiling in Oily Liquids. U.S.F.S. For. Prod. Lab. Rpt. 1665, 4 pp.
12. Anon. F 1957. Special Methods of Seasoning Wood. High Temperature Drying: Its Application to the Drying of Lumber. U.S.F.S., For. Prod. Lab. Rpt. 1665–1.
13. Anon. F 1956. Steam Requirements in Lumber Dry Kilns. U.S.F.S. For. Prod. Lab. Rpt. 1478 (rev.) 4 pp.
14. Anon. A 1956. Vacuum Drying of Wood. U.S.F.S., For. Prod. Lab. Rpt. 1665–5, 2 pp.
15. Ailport, J. L. A 1958. Seasoning degrade in kiln drying lumber. FPRS Wood Drying Div. News Digest, May.
16. Almeida, G. de A 1957. The drying of wood. Anu. Bras. De Econ. Florestal 9 (9):99–121. (English summary).
17. Biriukov, V. A. F 1957. (Drying and achieving moisture equilibrium in veneered laminae.) Suska i vyravnivanie vlaznosti fanerovannyh scitov. Derev. Prom. 6 (1): 11–2.
18. Biriukov, V. A. (spelling questionable) R 1956. (Modern Methods of Drying Lumber.) Sovremennye metody sushki dervesiny. Minsk, Gos., izd–vo BSSR, 263 pp.
19. Biriukov, V. A. R 1958. (Regularity of drying of sawed materials in compartment dryers.) Derev. Prom. 7 (6): 4–6.
20. Boije, R. L. A 1957. (Some memoranda on vaccum drying of lumber.) (Swedish) Paperi Ja. Puv. 39 (7): 352.
21. Bollman, L. F 1956. (Accelerated air drying.) Beschleunigte freilufttrocknung. Holz–Zbl. 81 (98):1173–4.
22. Bollman, L. F 1957. (Drying of timber with or without fans.) Holz–Zbl. 83 (125):1521–4.
23. Brough, J. C. A 1957. Electronic controls in dry kilns show moisture content. South. Lumberman 195, (2435): 28–29.
24. Brown, W. H. A 1957. The seasoning qualities of Podo (Podocarpus spp.) Timber Technol. & Mach. Wood Preservation & Seasoning 65 (2218): 423–4.
25. Brunn, G. A 1955. Importance of using kiln samples in drying of Radiata pine. New Zealand Timber J. and Forestry Review 2: 32.
26. Calvert, W. W. A 1958. High temperature kiln-drying of lumber–A summary of Canadian Processes. Forest Prod. J. 8 (7):200–204.
27. Campbell, G. S. A 1956. The drying of Keruing (Dipterocarpus spp.) C.S.I.R.O. Forest Products Newsletter. 220:3–4.
28. Campbell, G. S. A 1955. The drying of red meranti (Shorea spp.) C.S.I.R.O. Forest Prod. Newslet. 210:3.
29. Cantrell,W. R. A 1956. Vapor drying of western woods. For. Prod. J. 6:30–34.
30. Carruthers,J. F. S. F 1957. A survey of the principles of veneer drying in mechanical dryers. For. Prod. Res. Lab Princes Risborough.
31. Carter, R. M. A 1956. Force drying processes. Woodworking Digest 58 (10):96–98, 100.
32. Carter, R. M. A 1957. How does moisture content affect finishing? Woodworking Digest 59 (4):64–5.
33. Chernaev, P. A 1956. Investigations to determine the most appropriate methods and regimes of drying wood. (In Bulgarian.) *Sofia,* Vissh Lesoekh. Inst. Navch. Trudove 4:129–54.
34. Chrismer, R. F., and C. A. Hart. F 1958. A prediction equation for veneer drying schedules. For. Prod. J. 8 (4):137–41.
35. Cividini, R. A 1956. On the methods of kiln drying of wood. (In Slovenian.) Les (Ljubljana) 8:29–33.
36. Clark, J. W. A 1957. A gray, nonfungus seasoning discoloration of certain red oaks. South. Lumberman 194 (2418):35–8.
37. Clegg, W. A 1957. The effect and control of shrinkage during the kiln-drying of species of the genus Quercus. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning, 65 (2222):623–6.
38. Colgrove, W. H. F 1956. Chemical seasoning of lumber. For. Prod. J. 6 (10):417–9.
39. Colgrove, W. H. A 1956. Chemical seasoning of lumber. For. Prod. J. 6: 450–52.
40. Conners, W. M., and G. Bramhall. A 1957. An evaluation of factors affecting the rate of drying of round western hemlock. (Tsuga heterophylla) during the boling under vacuum process. For. Prod. J. 7 (6): 205–8.
41. Conway, E. M. F 1958. Factors that affect the cost of hardwood kiln-drying. For. Prod. J. 8 (1):21-A–24-A.
42. Currier, R. A. F High drying temperatures-do they harm Douglas-fir veneer? For. Prod. J. 8 (4):128–36.

43. Daskovskii, A. F. F 1956. (Automatic temperature regulator for steam heated kilns.) Avtoreguljator teplovyh processov v susil jnoi kamere Derev. Prom. 5 (1):17–9.
44. Devine, J. A 1958. A one-track mind? South. Lumberman 196 (2448): 51–52.
45. Devine, J. A 1958. Continual painting of dry kilns can hold down deterioration. Natl. Hardwood Mag. 32 (3): 36–37, 52.
46. Devine, J. A 1957. Proper use of temperature can save you drying money. Natl. Hardwood Mag. 31 (11):106, 108.
47. Devine, J. A 1957. Wet bulb theory of constancy is not necessarily so. Natl. Hardwood Mag. 31 (11)120–1, 128–9.
48. Dost, W. A. F 1958. Kiln Design. Air Circulation. Research project. Index No. 3.22113. Interims Report B. California Redwood Association, San Francisco.
49. Dumitrescu, N. S., D. Andriano, and M. Boiciuc. F 1955. (Studies with a view to establishing new seasoning schedules for oak (Q. Robur) stavewood and large beans of spruce). Cercetari cu privire la elaborarea unor noi regimuri de uscare pentra doagele de stejar si grinzile de molid de mari dimensiuni. Industr. Lemn. 4 (2): 58–65. (Rum.).
50. East, V. C. A 1957. The control of humidity and temperature in wood drying kilns. So. African Bldg. & Timber Trades J. 7 (4):12–18.
51. Efimov, G. V., and N. N. Stepanov. A 1956. Drying and impregnation of beech(wood) with petrolatum. (In Russian) Lesn. Promysh. 34(4): 15–16.
52. Elliott, R. H. A 1956. Prefabricated dry kiln buildings. For. Prod. J. 6:-17A–18A.
53. Enchev, E. A. A 1956. Measuring wood moisture at the point of fiber saturation. (In Bulgarian) Sofia. Vissh Lesotekh Inst. Nauch. Trudove 4: 125–8.
54. Engelmann, A. F 1956. (Drying problems in the manufacture of parquet flooring.) Probleme der holztruck in der parkettin dust rih. Holz–Zbl. 82, (68):840.
55. Escoff. A 1957. (Drying and conditioning of wood.) (In Italian). Cron. Econ. (177):31–4.
56. Fedorov, N. R. R 1958. (Drying wood in petrolatum. (Bivl. Tekh. Inform. 4 (1):15–16.
57. Fessel, F. A 1956. A turning point in the technique of drying; destroying and breaking off the boundry layer. Austral. Timber J. 22:125, 127–8, 131, 218.
58. Fessel, F. F 1956. (Practice of wood drying in the H. F. electric condenser field in different countries.) Die praktische durchfuhrung der holztrocknung im hoch frequenten elektrischen kondensatorfeld in vershiedenen landern. Holz Roh–u. Werkstoff 14 (2): 41–7.
59. Finighan, R. A 1956. New survey to measure moisture content of timber in use. C.S.I.R.O. Forest Prod. Newslet. 220:4.
60. Fleischer, H. O. A 1958. A graphic method of estimating veneer drying rates. U.S.F.S. For. Prod. Lab. Rpt. 2104.
61. Fleischer, H. O. A 1956. The longitudinal shrinkage of cativo (Prioria copaifera). Yale U. Sch. Forestry. Trop. Woods. 105:1–5.
62. Folomin, A. I. R 1957. (High temperature drying of lumber in petrolatum.) Gor. i Sel'. Stroi 1:23–5.
63. Folomin, A. I. A 1956. Rapid high-temperature drying in non-aqueous fluids. *Wood* (London) 21:220–4.
64. Folomin, A. I., and IA. V. Erokhin. R 1956. (Development of the method of artificial seasoning of lumber in petrolatum.) Stroi Pred. Neft. Prom. 1:24–6.
65. Folomin, A. I., and S. E. Shteinberg. R 1957. (Drying lumber in petrolatum.) Rats. i izobr. predl. v. Stroi 1:100–104.
66. Fountain, W. C. F 1956. Sticker losses. B. C. Lumberman 40 (9): 58, 60.
67. Frean, D. H. A 1957. A new type of lumber kiln. Malayan Forester 20 (3):151–2.
68. Glenn, H. E., and others. A 1956. Seasoning, Preservation and Water-Repellent Treatment and Physical Properties Study of Bamboo. Clemson Agr. College, S. C. Engin. Expt. Sta. B. 8, 186 pp.
69. Gottstein, J. W. A 1956. C.S.I.R.O. Screen drier for veneers. C.S.I.R.O. Forest Prod. Newslet. 215:6–8.
70. Gottstein, J. W., and B. McCombe. A 1956. Recent studies on "ash" type hardwoods (eucalyptus); collapse intensified by heating while green. C.S.I.R.O. Forest Prod. Newslet. 216: 1–2.
71. Graham, P. A 1956. Evolution of lumber drying. Wood Working Digest 58 (3):90–3.
72. Graham, P. A. 1956. Measuring air movement in dry kilns. Wood Working Digest 58 (10):62–4, 66, 68, 70, 72, 74, 76.
73. Graham, R. D. A 1957. Effect of several drying conditions on strength of coast-type Douglas fir timbers. For. Prod. J. 7 (7):228–33.
74. Grzeczynski, T. A 1956. (Investigations upon the anisotropy of hygroscopic deflection in the course of the seasoning of wood.) (In Polish) Sylwan (Ser. A). 100 (11):76–96. (English summary)
75. Guernsey, F. W. F 1957. High temperature drying of British Columbia softwoods. For. Prod. J. 7 (10): 368–71.
76. Gupta, H. K., and M. A. Rehman. A 1956. Shrinkage, swelling and equilibrium moisture content of wood, their importance in seasoning, and a new approach to the problem of ascertaining dimensional stability of timber. Timber Dryers and Preservers Assoc. India J. 2 (4):12–19.
77. Gurevich, V. Z. R 1957. (Experience in drying lumber in petrolatum.) Der. Prom. 6 (10):5–6.
78. Guseva, K. V. R 1956. (Time needed for drying pine and spruce boards and blocks in petrolatum.) Der Prom. 5 (8):13–14.
79. Hale, J. D. A 1957. The anatomical basis of dimension changes in wood in response to changes in moisture content. For. Prod. J. 7 (4):140–4.
80. Hammond, R. A 1958. Kiln drying of timber 1. Timber Technology 66 (2226):189–191.
81. Hammond, R. A 1958. Kiln drying of timber 2. Timber Technology 66 (2227):235–6.
82. Hammond, R. A 1958. Kiln drying of Timber 3. Timber Technology 66 (2228):296–8.
83. Hartwig, G. A 1957. Seasoning of wood at temperatures above 100° C. So. African Bldg. & Timber Trades J. 7 (5):12–20.
84. Holland, F. A 1956. Drying billets for broomheads. Austral. Timber J. 22:31–33, 105.
85. Huffman, J. B. A 1957. Feasible to kiln dry gum ties in 3–5 days. Cross Tie B. 38 (5):20, 22.
86. Huffman, J. B. A 1958. Kiln-Drying of Cross-Ties. FPRS Wood Drying Div. News Digest, Mar.
87. Huffman, J. B. A 1957. Kiln drying of hickory ties. Cross Tie B. 38 (11): 58–62.
88. Huffman, J. B. A 1958. Kiln drying of southern hardwood cross ties. For. Prod. J. 8 (6):165–172.
89. Huffman, J. B. A 1957. Th kiln drying of gum cross ties. Am erican Wood Preserv. Assoc. Proc 53:-163–78.
90. Iwasita, M., and M. Tanibu hi. F 1956. (Non uniformity in inte al-fan drying kilns, in particular th effect of the air-velocity distributi) J. Jap. Wood Res. Soc. 2 (1):8–
91. Jiru, P. F 1956. (Developme of a compartmental kiln for dryir con-verted timber at temperatures p to 100°C.) Vyvin komorove sus y na resivo pro teploty pod 100° C Drev. Vyskum 1 (½):195–223.
92. Johnston, D. D. A 1956. T kiln drying of home grown beech (gus). Timber Technol. and Mach. Wood-working, Wood Preserv. and ason-ing 64 (2210):631–3.
93. Johnston, D. D. A 1957. T kiln drying of home grown scots p e and imported redwood. Timber T hnol. and Mach. Woodworking, Wood Preserv. and Seasoning 65 (216): 300–2.
94. Kantor, S. I. F 1956. (Comp tment kiln plant charged from th top.) Lesosusil-naja kamera sahtnog tipa. Derev. Prom. 5 (11):14–5.
95. Karlsen, O. A 1957. (Advant ges of outdoor drying of wood.) (In Norwegian). Norsk Tretek Inst. Utredning 14:31–35.
96. Karlsen, O. F 1956. (Recent experiences with wood drying. Nyere erfaringer uedroren de tretorking. Norsk Tretek Inst. Utredning 12 (6): 10.
97. Kauman, W. G. A 1956. Current research on collapse. C.S.I.R.O. Forest Prod. Newslet. 221:1–2.
98. Kauman, W. G. F 1956. Equilibrium moisture content relations and drying control in superheated steam drying. For. Prod. J. 6 (9):328–32.
99. Kauman, W.G., and G. S. Campbell. A 1956. Seasoning of klinki pine (Araucaria klinkii) from New Guinea. C.S.I.R.O. Forest Prod. Newslet. 214:3–4.
100. Keer, G. A. A 1956. Air cir ulation in the drying kiln. Wood (L ndon) 21:314–16.
101. Keer, G. A. A 1956. Equipm nt for timber drying kilns and its m intenance. Wood (London) 21 (10): 390–2.
102. Keer, G. A. A 1957. High-t perature kilning 1–2. Wood (Lond n) 22 (10):416–17, (11):451–3.
103. Keer, G. A. F 1956. Kiln mples (their selection, preparation an use.) Wood (London) 21 (9):358- 0.
104. Keer, G. A. A 1956. Kiln Sc dules. Wood (London) 21 (2):62–6
105. Keer, G. A. A 1957. Prob s of Kiln operation. Wood (Lond) 22 (2):57–9.
106. Keer, G. A. A 1956. Publi Kiln drying. Wood (London) 21 11): 437–9.

107. Keer, G. A. A 1956. Recent developments in kiln design. Wood (London) 21 (12):474–7.

108. Keer, G. A. A 1958. Relative Humidity. Wood (London) 23 (8):354.

109. Keer, G. A. A 1956. Seasoning defects and degrade. Wood (London) 21:9–11.

110. Keer, G. A. A 1956. The after-care of seasoned timber. Wood (London) 21 ():98–100.

111. Keer, G. A. A 1956. The story of kiln drying 1. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning. 64:403–5.

112. Keer, G. A. A 1956. The story of kiln drying 2. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning 64:493–4.

113. Kelsey, K. E., and L. N. Clarke. A 1956. The heat of sorption of water by wood. Austral. J. Appl. Sci. 7: 169–75.

114. Kimball, K. E. F 1956. Devices that measure and control temperature in dry kilns. U.S.F.S. For. Prod. Lab. Rpt. 1654 (rev.) 12 pp.

115. Kininmonth, J. A. A 1957. Kiln drying pressure treated radiata pine. New Zealand Timber J. and Forestry Review 3 (5):41–43.

116. Knauss, A. C. A 1957. Seasoning Degrade in Kiln Drying Ponderosa Pine in South Central Oregon. U.S.F.S. Pacific Nwest. Forest Range Exper. Sta. Res. Note 136, 11 pp.

117. Koljo, B. A 1956. (Investigation of resin exudation in wood drying.) Untersuchungen uber den harzaustritt bei der holztrocknung. Hol als Roh–u Werkst. (14):89–94.

118. Kolb, H. A 1957. (Tensile stress and strain in wood perpendicular to the grain with respect to wood drying.) Spannungen und dehnungen im holz senkrecht zur faserrichtung in hinblick auf die holztrochnung. Chem. Ingen.-Tech. 29 (6):414.

119. Kollman, F. F 1957. (The economics of kiln drying.) Die wirtschaftlichkeit der kunstlichen schnittholztrocknung. Pap. ja Puu 39 (3):73–6.

120. Kollman, F., and A. Schneider. F 1956. A new laboratory dry-kiln constructed for investigations in a wide range of temperature, relative humidity and flow speed. Comp. Wood 3 (5/6):109–16.

121. Koltunouskaia, B. R 1957. (Rapid Drying of lumber in petrolatum.) Stroi. Mat. 3 (11):10.

122. Koning–Vrolijk, G. M. C. 1956. Shrinking of freshly cut ash wood in drying. A (In Dutch) Nederland Heidematsch Tijdschr. 67:144–6.

123. Koperin, F. I., and N. P. Fedysin. F 1957. (Natural seasoning of parcels of sawn lumber.) E stest vennaja suska pilomaterialov v paketah. Lesn. Prom. (7):26–8.

124. Koppel, R. F 1957. (The development of kiln drying of wood.) Zur entwicklung der kunstlichen holztrocknung. Holz–Zbl. 83 (24):301–4.

125. Koperin, F. I., and N. P. Fedyshin. 1957. (Natural drying of lumber in stacks.) (Russian) Lesn. Promysh. 35 (7):26–8.

126. Krasnovskii, L. V. A 1956. (Ways of achieving the norm requirements for quality in chamber drying lumber.) Der Prom. 5 (6):3–6.

127. Kretcetov, I. V., and B. S. Carev. F 1956. (Portable timber seasoning plants.) Transportabel nye lesosusil' nye ustanovki. Derev. Prom. 5 (7): 6–7.

128. Kretchetov, I. V. (spelling questionable) R 1957. (Improvement in drying lumber.) Les Prom. 35 (5): 129–31.

129. Kreuzer, A. F 1957. (Kiln drying of green beech wood in turbulent air- and spiral-air-circulation driers. Holz-Zbl. 83 (140/141):(1705).

130. Krpan, J. A 1956. (Moisture content in green beech wood.) Sumarski List 80 (11/12):386–92.

131. Kruml, J. F 1956. (Seasoning of wood in liquids.) Vysouseni dreva v kapalinach. Drevo 11 (2):47–51.

132. Ladell, J. L. A 1958. High-temperature kiln-drying of Eastern Canadian softwoods. *Austral.* Timber J. 24 (3): 64, 67, 69–70, 73–74, 76, 80.

133. Ladell, J. L. F 1957. High-temperature kiln-drying of Eastern Canadian softwoods: drying guide and tentative schedules. F.P.L. Tech. Note For. Prod. Lab. Can. No. 2, 18 pp.

134. Ladell, J. L. A 1956. High-temperature drying of yellow birch (Betula alleghaniensis). For. Prod. J. 6: 469–75.

135. Leont'ev, N. L. F (Effect of high temperature drying schedules on the physical and mechanical properties of wood.) Vlijanie vysoko temperaturnyh rez imov suski na fizikomehani ceskie svojstva drevesiny. Drev. Prom. 5 (10):3–5.

136. Lent'ev, N. L. R 1957. (Effect of high temperature drying of pine wood on its physical and mechanical properties.) Derev. Prom. 6 (6): 3–6.

137. Loughborough, W. K. A 1956. The benefits to be gained from a dry kiln club. South. Lumberman 192 (2398): 42–3, 46.

138. MacLean. J. D. F 1956. Seasoning and checking of timbers before and after (preservative) treatment. Proc Amer. Wood Pres. Assoc. 52:35–48.

139. Mathewson, J. S., and P. J. Berger. A 1957. Comparison of three methods of determining whether southern pine poles are well seasoned. For. Prod. J. 7 (5):174–77.

140. McLaughlin, T. P. A 1957. Automation in kiln operation. Wood Working Digest 59 (5):37–40.

141. McMillen, J. M. F 1956. Seasoning Hickory Lumber and Handle Blanks. Hickory Task Force Rpt. S. East For. Exp. Sta. No. 4 36 pp.

142. McMillen, J. M. F 1956. Special Methods of Seasoning Wood. Boiling in Oily Liquids. U.S.F.S. For. Prod. Lab. Rpt. 1665 (rev.) 4 pp.

143. McMillen, J. M. F 1957. Special Methods of Seasoning Wood. Chemical Seasoning. U.S.F.S. For. Prod. Lab. Rpt. 1665–6 (rev.) 3 pp.

144. Milhailov, Iv. A. R 1956. (The part played by N. P. Bulygin in the development of the dry technique.) (In Russian.) Latv. Psr. Zinatnu. Akad. Vest. 6:107–12.

145. Mikit, E. A., and K. K. Upmanis. R 1958. (Efficient design of chambers used for intense drying of lumber.) Derev. Prom. 7 (7):5–7.

146. Mikit, E. A.,and K. K. Upmanis. R 1957. (Intensifying the Drying of Lumber in Chambers Operating on a Cycle.) Intensifikatsiia sushki pilomaterialov v kamerakh periodicheskogo deistviia. Moskva Goslesbumizdat, 41 pp.

147. Miller, D. J., and R. D. Graham. A 1957. Seasoning and Preservative Treatment of Tanoak Lumber (Lithocarpus densiflorus). Ore. For. Prod. Lab. Rpt. P–3, 8 pp.

148. Morozov, N. A. R 1958. (Automatic control in drying shops of woodworking enterprises.) Mekh. Trud. Rab. 12 (5):6–9.

149. Nakagawa, H. F 1957. (On the drying of match splint chips with a rotary dryer.) J. Jap. Wood Res. Soc. 3 (4):154–7.

150. Naumov, D. L. R 1956. (Drying Beech lumber in clamps.) Derev. Prom. 5 (9):21–2.

151. Noack, D. F 1958. (Notes on pulsation drying methods.) Bemerkungen zum pulsationstrocken verfahren. Holz-Zbl. 84 (34):481.

152. Ogura, T., and M. Umehara. F 1957. (On the effect of temperature, fiber-direction and thickness of board on the diffusion coefficient of wood). J. Jap. Wood Res. Soc. 3 (2):51–6.

153. Page. R. H., and R. M. Carter. A 1957. Heavy Losses in Air Seasoning Georgia Pine and How to Reduce Them. U.S.F.S. S.East For. Expt. Sta. Paper 85, 20 pp.

154. Page, R. H., and R. M. Carter. A 1958. Variations in moisture content of air seasoned southern pine lumber in Georgia. For. Prod. J. 8 (6):15–A, 18–A.

155. Patrushev, I. N. R 1957. (Using electric heaters for drying lumber in petrolatum.) Stroi. Prom. 35 (11):34–6.

156. Peck, E. C. F 1957. Air drying and sticker stain of 4/4 sugar maple flooring stock in Upper Michigan. U.S.F.S. For. Prod. Lab. Rpt. 2086

157. Peck, E. C. A 1956. How can sticker stain in hardwood lumber be prevented? U.S.F.S. For. Prod. Lab. Rpt. 1769–23, 3 pp.

158. Peck, E. C., E. S. Kotok, and L. A. Mueller. A 1956. Air drying of Ponderosa pine lumber in Arizona. For. Prod. J. (6):88–96.

159. Perkintny, T., J. Stefaniak, and Z. Rudnicki. F 1957. (Effect of compression stresses on the swelling and shrinkage of wood.) Wplyw naprezen aciskajacych na necznienie i kurczenie sie drewna. Prace. Inst. Tech. Drewna 3 (4):52–69.

160. Perkitny, T., M. Zenkteler, and M. Wnuk. F 1957. (Influence of the duration of the conditioning of wood on the equalization of its moisture content.) Wplyw czasu klimatyzowania drewna na wyrowynwanie sie jego wilgotnosci. (Pol.) Prace Inst. Tech. Drewna 3 (4):3–14.

161. Pope. E. M. A Today's prefabricated dry kiln. For. Prod. J. 6:19–A–20–A.

162. Pratt, W. E. F 1956. Estimating the moisture content of lumber during the drying process. For. Prod. J. 6 (9):333–7.

163. Rasmussen, E. F. F 1956. Need for uniformity of temperature in a forced-air-circulation, ventilated compartment dry kiln. U.S.F.S. For. Prod. Lab. Rpt. 1669 (rev.) 5 pp.

164. Rehman, M. A. A 1956. The seasoning behavior of Indian Timbers III. Indian Forester (82):252–59.

165. Rehman, M. A., J. Kishnen, and O. P. Chawla. A 1956. A note on case-hardening of timber during seasoning and its removal. Timber Dryers and Preserv. Assoc. India. J. 2 (3): 5–6.

166. Rehman, M. A., and J. Kishen. A 1956. Kiln seasoning in India VII. Timber Dryers and Preserv. Assoc. India J. 2 (2):17–18.

167. Rehman, M. A., and A. C. Sekhar. A 1956. Chart for selecting tentative kiln drying schedule for seasoning of new timber. Timber Dryers and Preserv. Assoc. India. J. 2 (3):11–17.
168. Richards, D. B. A 1958. High Temperature Drying of Southern Hardwoods. Ala. Agr. Expt. Sta. C. 123. 12 pp.
169. Rietz, R. C. A 1957. Importance of Dry Lumber. U.S.F.S. For. Prod. Lab. Rpt. 1779.
170. Rietz, R. C. A 1957. What are the advantages and disadvantages of the package loaded dry kiln? Austral. Timber J. 23 (3):98, 100.
171. Sakhnovskii, L. V., and N. S. Korin. R 1957. (Multi-unit remote-controlled psychrometer.) Derev. Prom 6 (12): 6–8.
172. Sahnovskii, L. V., and N. V. Krasnovskii. F 1956. (The final moisture conditioning and checking of the condition of wood after seasoning.) Konececnaja valagoobrakotka i kontrolj so stojanija drevesinv posle suski. Derev. Prom. 5 (1):5–8 (Russian)
173. Sandmo, J. K. A 1956. Floor Boards (Drying) (In Norwegian). Norsk Skogindus 10:321, 323.
174. Schniewind, A. P. A 1956. Sorption Hysteresis in relation to wood thickness. For. Prod. J. 6:225–9.
175. Shcherbakovskii, V. Ia. R 1957. (Drying Wood in Petrolatum: Practices of the Repair and Construction Trust of Zheleznodorozhnyy District in Moscow.) Sushka Drevesiny v Petrolatume; iz Optya Remontno-stroitel'nogo Tresta Zheleznodorozhnogo Raiona Moskyy. Moskva. Izd-vo M-va Kummun. Khoz. RSFSR 70 pp.
176. Shteinburg, S. E. R 1956. (Practices of high temperature drying of wood in Petrolatum.) Derev. Prom. 5 (10): 6–8.
177. Shubin, G. S. R 1958. (Method of calculating the drying time of thin lumber.) Nauch. Dokl. Vys. Shkoly: Lesoinzh. Delo. (1):156–60.
178. Shubin, G. S. R 1958. (Heat exchange and mass transfer in drying veneer sheets at high temperatures.) Nauch. Dokl. vys. Shkoly: Lesoinzh. Delo. (2):132–7.
179. Siimes, F. E. A 1956. On Kiln drying. (In Finnish) Paperi Ja Puu (33):303–8, 310.
180. Smirdin, P. M. R 1957. (Conditions for drying blank beech blocks.) Derev. Prom. 6 (4):14–15.
181. Smith, H. H. A 1956. Improving utilization of western hardwoods by modern drying. For. Prod. J. (6): 121–4.
182. Smith, H. H., and C. P. Berolzheimer. A 1957. Air Drying of Incense Cedar: Tests Under Summer Conditions in California. U.S.F.S. Calif. For. and Range Expt. Stat. For. Res. Notes. 123, 10 pp.
183. Sokolov, P. V. R 1956 (Accelerated Methods of Drying Wood: Dry Kilns and Drying in Hydrophobic Liquids.) Uskorennye sposoby sushki; drevensiny: Kamernaia sushka i sushka v gidrofobykh zhidkostiakh. Moskva. Goslesbumizdat, 81 pp.
184. Solov'ev, E. A 1956. (Faster drying of wood.) (In Russian.) Sel'sk Stroitel' 11 (6):12–15.
185. Stefan, A. F 1957. (Kiln seasoning of hornbeam timber.) Uscarea artificiala a lemnului de carpen. Industr. Lemn. 6(2):53–6.
186. Stejnberg, S. E. F 1956. (Practical experience in the high-temperature seasoning of wood in petrolatum.) Praktika vy soko tempera turnoj suski deveriny v petrolatume. Derev. Prom. 5 (10):6–8.
187. Stevens, W. C. A 1956. Kiln Schedule determination. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning 64:308.
188. Stevens. W. C. A 1957. The significance of certain factors that affect the drying of a load of timber. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning 65 (2220):509–10.
189. Stevens, W. C. A 1956. Timber drying in Scandinavia. Timber Trades J. 217 (4155):81–2, 91.
190. Stevens, W. D.,D. D. Johnston, and G. H. Pratt. A 1956. An investigation into the effects of air speed on the transference of heat from air to water. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning. 64:537–9.
191. Stevens, W. C., and D. D. Johnston. A 1957. Temperature drop across a pile of green lumber and its effect on drying rates. Timber Technol. and Mach. Woodworking, Wood Perserv. and Seasoning 65 (2212):73–5.
192. Stevens, W. D., and G. H. Pratt. F 1958. A single stack overhead horizontal fan kiln. Wood 23 (5):205–7.
193. Stevens, W. C., and G. H. Pratt. F 1958. The effect of air speed and flow direction on the drying of a pile of timber. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning 66 (2225):121–3.
194. Stillwell, H.D. A 1957. Initial Study of Kiln Drying Clear Douglas Fir (Pseudosuga menziesii) Planks. Oregon For. Prod. Lab. Rpt. D–4, 9 pp.
195. Suzuki, Y. F 1956. (Shrinkage of wood in kiln drying.) J. Jap. Wood Res. Soc. 2 (1):43–8.
196. Teesdale, L. V. F 1956. Dry Kiln Building Materials and Construction. U. S. D. A. For. Prod. Lab. Rpt. 1646 (rev.) 10 pp.
197. Terazawa, S., S. Sato, and M. Nohara. A 1957. (An experiment on a timber-dryer of Hillbrand, type Hd74, with a small furnace.) (In Japanese) Rin-Go-Shiken-Hokoku (93):131–46.
198. Terazawa, S., and T. Tutumoto. F 1957. (A hot wire anemometer applicable to lumber dry kiln.) Bull. For. Exp. Sta. Meguro, Tokyo (97): 163–73.
199. Terazawa, S., and M. Kodama. F 1957. (Fundamental study on the operation of wood drying. III. A simplified estimation of drying time in kiln drying.) Bull. For. Exp. Sta. Meguora, Tokyo (97):61–72. (Japanese)
200. Terazawa, S., and M. Kodama. F 1957. (Fundamental study on the operation of wood drying. II. On the characteristic curve in wood drying (2).) Bull. For. Exp. Sta. Meguro, Tokyo (93):89–96. (Japanese)
201. Tiemann, H. D. A 1956. The development of kiln-drying during the last 75 years. South. Lumberman 193 (2417):230–234.
202. Tinto, J. C. F 1957. (Treatment of eucalypt timber. Correction of collapse in E. globulus.) Tratamiento fisico de madera de eucalipto. Correccion del colapso en eucalyptus globulus labill. Rev. Invest. For. B. Aires 1 (1/2):123–51. (Spanish)
203. Tsarev, B. S. R 1957. (Investigating the kiln drying of pinewood.) Derev. Prom. 6 (4):4–6.
204. Tutumoto, T. F 1957. (Studies on the control of end splits during drying of veneer.) J. Jap. Wood Res. Soc. 3 (1):20–3.
205. Uglov, B., and B. Tsarev. R 1958. (Increase the producitvity of drying chambers.) Prom. Koop. 12 (6):28–9.
206. Ugolev, B. N. R 1957. (Analyzing stresses in wood during the drying process.) Derev. Prom. 6 (4):8–11.
207. Ugolev, B. N. R 1957. (Analyzing streses in wood in the process of drying.) Derev Prom. 6 (5):10–12.
208. Urbanik, E. F 1957. (Studies on the seasoning of beech wood in organic vapors.) Z badan nad suszeniem drewna bukowego w parach [illegible]ieczy organicznych. Przem. Drzewny 8 (8): 25–8 (Polish)
209. Villiere, A. F 1957. (High Frequency and Wood Drying.) Trans. For. Prod. Lab. Can. No. 114, 5 pp. Trans from Rev. Bois. Appl. 12 (1):26–8.
210. Vintila, E. F 1956. (Seasoning beech veneer in petrolatum.) Cercetari asupra uscarii furnirului de fag in petrolatum. Industr. Lemn. 5 (12):5 5–23.
211. Villiere, A. A 1956. Seasoning of Lumber by High-Frequency Currents. Trans. For. Prod. Lab. Can. No 103, 12. pp. Trans. from Rev. Bois. Appl. U. (1):26–31.
212. Vintila, E., H. Roman and E. I[illegible]ciuc. F 1957. (Seasoning of beech veneer by the use of volatile organic agents.) Industr. Lemn. 6 (3):95–8.
213. Vodoz, J. F 1956. (A new experimental set-up for studying the behavior of various wood species in H. drying.) Holz--Roh-u Werkstoff 14 (10):407–9.
214. Vodoz, J. A 1957. (The behavior of wood during drying with high frequency.) Das verhalten des holzes webrend der trocknung im hochfrequenten wechselfeld. Holz als Roh-u Wekst. 15 (8):327–40.
215. Wallen, G. A 1956. (Drying of wood at high or low temperature.) (In Swedish) Travaruindustrien 2:26, 28, 30.
216. Watanabe, H., and K. Aso. F 1957. (Studies on the transmission of gas through wood II. On the relation between gas pressure and transmission velocity of gas parallel to the grain through sapwood and heart of sugi (Cryptomeria japonica). J. Jap. Wood Res. Soc. 3 (2):41–5.
217. Wilks, W. E. A 1957. Flue gas drying. Austral. Timber J. 22 (12):201–2.
218. Williams, L. A 1958. An investigation into the reabsorption of moisture in timber after drying. Timber Technol. and Mach. Woodworking, Wood Preserv. and Seasoning 66 (2224): 73–5.
219. Winkel, L. D. A 1956. Case hardening stress relief of ponderosa pine. For. Prod. J. 6:124–128.
220. Woollett, H. B. A 1956. Kiln drying and the effect on tanalised timber. New Zeal. Timber J. and Forestry Rev. 2 (5, ie. 6):25, 32.
221. Wright, G. W. F 1956. Seasoning (of Eucalypts.) Final Rep. World Eucalyptus Conf. Rome, 1956:1 [illegible]-80.
222. Wright, G. W. A 1957. Stacking, handling, and kiln drying in Australia. Austral. Timber J. 23 ( ):51, 53, 57–8, 60, 63–4, 71–2, 75, [illegible]8.
223. Wynne, H. R. A 1957. Prop air-seasoning practices. South. Lumberman 194 (2426):56.
224. Youngs, R. L. F 1957. Mechanical properties of (Northern) red [illegible] related to drying. For. Prod. J. 7 10): 315–24.

Review of Chemical Utilization[1]

I. A. Pearl and A. S. Gregory
Vice-Chairman and Chairman, FPRS Chemical Utilization Division

Primary emphasis in this year's review is on the chemistry of lignin and of wood extractives. Also included are sections on charcoal, bark utilization, hydrolysis and hydrogenolysis, and pulping, plus an extensive bibliography.

CHEMICAL UTILIZATION OF WOOD for production of cellulose has enjoyed enormous success and is the basis of several large and expanding industries. In 1957, nearly 18 million tons of chemical wood pulp were produced, with a value well in excess of two billion dollars (16,90). About one million tons of this cellulose were chemically converted into plastics, rayon and acetate products, cellophane, sponge, explosives and other products that had a value in excess of a billion dollars (16,90). The remainder of the pulp went into paper and board products at a wholesale value of 10.7 billion dollars (16).

As a by-product of pulp manufacture, about 16 million tons of organic matter are produced. These organics are used to only a small extent, except as fuel, and may be regarded as a wood waste. In addition, logging operations associated with the pulp and timber industries annually result in about 50 million tons of left-overs in the forests, and lumber and plywood manufacture contribute another 45 million tons of residuals at the plants (252). Because of national interests involved in forest conservation, and because of the great potential of these wastes as raw material for new products, much research and development effort is directed toward utilization of these wastes. Chemical utilization is regarded as one of the more promising approaches.

A good deal of progress has been made in this area, despite the numerous, difficult and complex technical and economic problems. The degree of success may be judged from Table I, which indicates the dollar value (90,183) of chemicals derived from woody materials or pulp mill residues that were once primarily waste. Other wood-derived chemicals, including gum naval stores, natural tannins, natural dyestuffs and botanical drugs, have an annual value of approximately 35 million dollars (90).

As new plants come on stream each year, the dollar value of chemicals from wood increases slowly but steadily. In the years ahead, the wood chemical industries can anticipate additional progress with a high degree of confidence as the impact of research and development effort continues to make itself felt.

Developments in Charcoal Production and Use—1958

The popularity of charcoal for outdoor cookery has continued to increase. The resulting demand for charcoal has been offset partially by a decline in industrial requirements. The widespread public use of charcoal has led to corresponding interest in its manufacture, and numerous papers have been published.

An important conference on charcoal production and use was sponsored by the Northeastern Wood Utilization Council. The meeting was at New Haven, Conn., and was attended by over 100 men. An attendance list, with business affiliation, was prepared (19). Several of the papers have been published, including some of the discussion. Simmons (367) explained the council's concern for the utilization of cull-type trees, charcoal production being one of the answers to this problem. The report of the National Survey of Charcoal Production, made in 1957, was interpreted and supplemented by Hair (169). In 1956, the latest year for which data are available, 125,000 tons of charcoal briquettes were produced, up 28 per cent over 1955. About half of the charcoal production of 265,000 tons was used for food preparation. There were about 240 manufacturers of charcoal.

Hampf (171) reported on Production and Sale of Charcoal in the Northeast. His analysis included type of carbonization equipment, cycle times, charcoal yield, cost of wood, and prices received for charcoal. Charcoal production in Canada for 1955 amounted to 9,050 tons as reported by Risi (330). All of this production was in the province of Quebec where brick beehive kilns are preferred. The construction and operation of such kilns were described in some detail.

Beglinger (51) reported on the Forest Service development work on charcoal kilns. They have modified the original Hicock masonry block kiln to include double-wall construction, cubical-shaped carbonizing chamber, and steel doors. Some operating results were given. Charcoal kiln temperature control by use of a microammeter and thermocouples was explained by Peter (317), who also discussed ignition procedure and air regulation.

Haigh (167, 168) gave procedures for briquetting charcoal and listed the various items of equipment needed. Grothe (162) pointed out the importance of labor cost in operating cinder-block kilns, and noted some steps toward mechanization. Along this same line, Simmons (368) reported on the use of steel pallets to load and unload cinder-block kilns.

Table 1.—DOLLAR VALUE OF CHEMICALS DERIVED FROM WOOD WASTE IN THE UNITED STATES

	Thousands of $
Acetic acid, methanol, and other	$ 3,385[1]
Charcoal	11,929[1]
Wood naval stores	61,775[1]
Tall oil	15,000[2]
Kraft lignin products	7,000[3]
Lignosulfonates	5,053[2]
Vanillin	4,500[4]
Ethyl alcohol	1,635
Yeast	1,490
Total	$111,767

[1]1954.
[2]1956.
[3]Year not states.
[4]Estimated from production and sales volume.

[1] The authors acknowledge the contributions to this review of Edward Beglinger, J. F. Harris, E. G. Locke, F. A. Simmonds, and J. W. Rowe of the U. S. Forest Products Laboratory; L. E. Dowd and A. K. Esterer of Weyerhaeuser Timber Co.; and A. W. Goos of Cliffs-Dow Chemical Co.

[2] Numbers in parentheses refer to the Literature Cited at the end of this review.

The Authors: Irwin A. Pearl is Senior Research Associate and Chief of the Lignin Group at The Institute of Paper Chemistry, Appleton, Wisconsin. He graduated from the University of Washington with a BS in 1934, MS in 1935, and PhD in 1937. After several years on the University of Washington staff, he joined the Institute in 1941.

A. S. Gregory holds a BS from Oregon State College and a PhD from Ohio State University. He was formerly research chemist at duPont Experimental Station, Wilmington, Del., served in the Army Chemical Corps during World War II, and is now Director of Central Research and Development, Weyerhaeuser Timber Co., Technical Center, Longview, Washington.

Jenner (208) gave the history and description of the Cliffs–Dow Chemical Plant, said to be the world's largest charcoal producer. Industrial grades of charcoal and chemical by-products were mentioned, including some of their uses. It was pointed out that the wood distillation industry is an outstanding example of the utilization of cull material from the forest.

Beglinger (50, 53) stated that production of charcoal in kilns can be profitable, if low-cost sawmill waste is available. Research and cooperative industrial efforts are needed to help solve some of the industry's problems. The Forest Service has such research under way and has developed double-wall kilns of 2- to 7-cord capacity. Coaling time may be reduced by one-half by means of 3 stacks and single-air entry control. Moderate temperature can be maintained and charcoal yields of 28 to 32 per cent obtained.

Although most charcoal kiln operators produce less than 1,000 tons per year, one of the largest producers has 45 kilns and can produce up to 1,200 tons per month. A brief description of this plant has been published (20). "Flychar" is a term for carbonized particles of wood that escape complete combustion in hogged-fuel boilers used by some wood processors. One company in the Pacific Northwest has collected and transported this material to a central briquetting plant (22).

The increased use of charcoal for barbecuing and outdoor grilling has caused problems and a major change in marketing. Beazley (44) analyzed charcoal marketing in the United States according to economic theories and the results of several surveys to suggest answers to some of the marketing problem. Several short articles dealing with marketing charcoal appeared (45, 78, 216, 316).

The distillation of resinous wood as practiced in the South was reviewed by Beglinger, with general information on the methods and products (52).

With increasing demands for recreational charcoal, interest and activity was stimulated in production methods somewhat different from the usual pattern of practice. This was apparent in the efforts of both domestic and Canadian operators to utilize and convert wood fines continuously. While the greater emphasis in this field appeared directed toward fixed processing equipment, it is of interest to note that conversion conducted in a portable unit has been reported commercially satisfactory in a small plant in Ontario. There is included with this horizontal multiple tube carbonizing equipment, facilities for briquetting the resultant charcoal as well. This type of integrated processing developed in Canada is said to have a production capacity of one ton of briquettes each 8-hour period with expansion possibilities to 10 tons every 24 hours.

Further Canadian construction comprising multiple, vertical retort conversion of wood fines (21) has been made. It is reported that full production will be under way the latter part of this year. The utilization of unwanted cedar as the raw material for charcoal briquette manufacture is of primary concern to this British Columbia plant. The anticipated markets for the briquettes relate mainly to recreational use. These markets have been estimated as doubling their demand amounts each year for the past three years.

Installations of comparatively small vertical retorts, mainly in northeastern areas, which operate individually and stress features of portability and continuous conversion of mill slab and roundwood sections indicate considerable interest also in increased production and return. Operations employing these different but somewhat similar processing methods and equipment have been producing commercially during the past year. Without direct observation it would appear that the principle of conversion common to all is in the use of reaction heat combined with the recycling of heated wood gases and possibly the gases resulting from combustion of part of the wood gases.

Reference has been made to wood distillation plant modernization (18) in Great Britain. Current modifications of facilities for the plant include the use of a vertical carbonization tube 55 feet long and 6 feet in diameter of stainless and heat-resisting steel with the lower part of mild steel. Beech, birch, ash, sycamore, oak, and chestnut cordwood diameter sections about 12 inches long and predried to 12 to 14 per cent moisture content provide the continuous-feed raw material to the retort. The tube is equipped with airlock chambers at the upper and lower ends for periodic introduction of weighed amounts of wood and discharge of charcoal, respectively. For the distillation effect, a hot zone (temperatures varying from 450° to 550° C.) is maintained at about midtube height by reaction heat and by heat from combustion of washed wood gases. The heating use of the latter is described as "part is burned in an external furnace, situated opposite the hot zone of the retort; part is given a further water wash before being admitted to the lower part of the retort to cool the charcoal, and the balance of the gas which is not required for heating the retort is passed to the predryer furnace for drying the wood." Plant modernization as well includes methods and equipment comparable to those employed in this country for recovery of by-product chemicals.

Deepening of the trend to briquette manufacture conducted by way of alliance and cooperation of domestic briquetting plant and kiln operations was apparent throughout the year. More kiln construction associated with such manufacture and for providing conventional bagged lump supplies has been noted. Corresponding evidence can be indicated in the increase of briquetting plants from 20 to 37 in number over approximately the past year. The majority of these more recently installed briquetting plants rely upon separated sources of kiln charcoal production.

An outstanding example of construction and operational changes that has occurred to meet current production conditions is shown in the development of one of the newer kiln operations under way in the southeast. In connection with production from the larger kilns there has been general acceptance only of the traditional brick beehive (54) construction for units holding as much as 70 to 90 cords of wood Several of the 15 units anticipated for location in the southeast have been installed with poured concrete as construction material and capacities of 100 cords of wood each. Present plans are that the charcoal production from these kilns will be absorbed as the briquetting material for a nearby plant.

Chemical Utilization of Bark

Recent literature related to bark chemistry and chemical utilization has been mainly concerned with isolation and characterization or identification of extractives. The usual approach has consisted of extraction with a solvent, isolation of pure chemicals from the crudes, usually by chromatography, and identifications by classical techniques of organic chemistry. Most products isolated were phenolic, phenolic-glucosides, lignans, fatty acids, or sterols. Composition and properties of bark extractives were reported for the bark of Shasta red fir (48, 49), spruce (121, 122, 123, 158, 159, 187, 194), aspen (195, 196), yellow poplar (108), and cedar and larch (187). Other products isolated from the extractives of exotic barks included new alkaloids and triterpenes. Such barks were *P. densiflora* (180), *Sapium serbiferum* (257), *Chin–Pi–Ying* (92), *F. dissosperma* (60), *Schnopsis balansae*, (222), *Tectona grandis* (7), *Strychnos pseudo-quina* (11), *Ervatamia coronaria* (325), *Himandra belgraveana* (67), *Phebalium nudum*,

(75), *Takini* (56), *Intsia bijuga* (237), *Melia azadirachta* (356), *Kurchi* (384), *Phyllanthus emblica* (250), *Strychnos toxifera* (41), and *Mitsumata* (357). Products formed on oxidation of phenolic acids from white-fir bark were isolated and identified (130).

Tannin properties and composition were reported for bark of *Pinus radiata* (13), spruce (58, 59, 66), apple tree (320), *Ceriops roxburghiana* (324), *Betula alba* (9), and *Schnopsis* (223a). Fractional extraction of black wattle tannin was discussed (12).

Patents were issued to Rayonier, Inc. for manufacture of resins from bark derivatives (188, 373). Patents were issued covering a process for countercurrent extraction of bark (333) and for fractionation of bark (101). Availability of quercetin from Douglas-fir bark in pilot plant quantities was announced by the Weyerhaeuser Timber Co. (17).

Douglas-fir and ponderosa pine bark were reported to improve strength and water resistance of hardboard (12). Spruce and pine bark were reported to yield a low calorific content gas on pyrolysis (401). Chemical uses of bark were discussed (14, 252).

Wood Hydrolysis and Hydrogenolysis, 1957 and 1958

Wood hydrolysis continues to be of considerable interest. A total of 66 papers are included in this review. Russia contributed 45 per cent of the papers. In Russia, a separate journal covers wood hydrolysis and wood chemicals; 14 wood hydrolysis plants are reported to be operating there. Hydrolysis with sulfuric acid continues to attract a major share of the research effort. Experience has been gained with semicontinuous hydrolysis with dilute sulfuric acid (117). Extractives of pinewood seem to stabilize the sugars formed in the process (240). Hydrolysis with strong sulfuric acid (70 per cent and higher) has received attention (200, 297, 298) and the kinetics have been studied (294). Additional patents were issued to cover hydrolysis with hydrochloric acid by the Bergius (Rheinau) process (329). Similar processes have been investigated in Russia and Japan (296, 299). Hydrolysis of cellulose with hydrofluoric acid is facilitated by using polyethylene equipment (334).

Alkaline hydrolysis seems to proceed by "peeling" terminal sugar units (253). Extensive depolymerization of carbohydrates and lignin in wood can be brought about by impregnation of wood with alkali, followed by brief, high-pressure steaming (371).

Several inorganic salts and organic compounds, such as urea, reduce the rate of hydrolysis and inhibit the decomposition of sugars formed; other salts accelerate hydrolysis and decomposition of sugars in dilute sulfuric acid (398). Hydrolysis is facilitated by a thermal pretreatment, but is retarded by the presence of strong hydrogen bonds (361) that are formed with polar solvents. Diffusion through chips may cause loss of sugar yields up to 10 per cent, wood basis (234). Recovery of sulfuric acid by electrolysis is possible (228). Instrumentation of hydrolysis plants has been described (247). Hydrolysis of lignin and native lignin yielded several aromatic aldehydes (141). In hydrolysis lignin, the heterocyclic components may be combined with protocatechuic acid by ether bonds (242). Several modifications of lignin to obtain useful secondary products have been described (115, 205, 304, 358). Manufacture of ethanol continues to merit attention; yield increase by process manipulation, economics, and effluent problems have been discussed (35, 55, 112).

Partial hydrolysis is used widely in the wood pulping industry (prehydrolysis) and is properly included in respective reviews. Some aspects of partial hydrolysis belong in this review, such as selective hydrolysis of non-cellulosic constitutents with water under pressure (204), rate studies of pentosan hydrolysis with dilute sulfuric acid (229), and chemicals from prehydrolysis. The USSR claims to have a potential of 10 million tons of ethanol and 3250 tons of furfural from prehydrolysis in the near future (215). Hydrolysis with dilute sulfuric acid takes place in two steps: (a) hydrolysis of hemicellulose, (b) hydrolysis of alpha-cellulose (190). Strong sulfuric acid hydrolyzes cellulose in three steps: (a) micelle formation, (b) separation of micelles into chains (rate-determining), (c) hydrolysis of glucose chains (24, 267, 295). In agreementwith this mechanism, diffusion and penetration rate of acids were found to be limiting factors (127, 360) and over-all rate of hydrolysis can be increased by preswelling (362).

It was confirmed that amorphous areas in cellulose are hydrolyzed at a faster rate than the crystalline areas (254, 364). The rate of alcoholysis is related directly to the magnitude of the accessible surface area (363). Both acid and alkaline hydrolysis are influenced by steric factors in a similar way (114). Effects of extractives and of reactions of dissolved hemicelluloses have been measured (102). Several enzymes may be involved in the enzymatic hydrolysis of cellulose (284, 328). The presence of oxygen does not affect hydrolysis of cellulose but causes formation of carboxyl groups in the products (197, 198).

The hydrolysis of wood has been used as a tool to gain information relative to the structure of wood. Tension wood in *Eucalyptus goniocalyx* and *Pinus radiata* contains considerable quantities of galactose in the hydrolyzate of the noncellulosic polysaccharides (355). Presence of methoxyl in both the aliphatic and aromatic moieties of wood has been confirmed (387). Occurrence of *p*-hydroxybenzoic acid seems to be limited to the genera *Populus, Salix* and *Catalpa* (314, 315). Substances structurally related to thujic acid may exist in Douglas-fir wood (157). Alcoholysis of pine sapwood by Hibbert's method produced two additional, not-yet-defined phenols (203). Rate of acloholysis is greater in media of low polarity, presumably because they interfere with crystallization of amorphous areas of cellulose (235). Catalytic activity of mineral acids increases with increasing alcohol content, that is with decreasing ionization (236, 264), which indicates that hydrolysis of cellulose proceeds through formation of intermediate addition compounds instead of catalysis by hydrogen ions.

Cotton cellulose, polysaccharides and hydrolysis lignin were hydrogenated under heat and pressure with various catalysts. Products were unidentified (33, 148, 341). Among the products of the alkaline hydrogenation of maplewood, six phenolic compounds were identified (27).

Several reviews of hydrolysis with acids were published (238, 251, 345, 354, 359, 392).

Two doctoral theses concerned with the utilization of carbohydrates were released (262, 325). These deal with the acid-catalyzed degradation of sugars in aqueous solution. The kinetics of the conversion of xyloses to furfural in aqueous sulfuric acid solutions were studied over a temperature range of 160 to 280° C. at 20°C. intervals, an acid concentration range of 0.8 to 0.00625 gram equivalents per liter, with the initial xylose concentration varying from 3.125 to 200 grams per liter. Investigation of other mineral acids and salts is also reported in this work. Furfural yields from xylose increase with increasing temperature and decreasing xylose concentrations; the acid concentration has no effect on yield when above 0.1N sulfuric acid. The results indicate that favorable yields of furfural can be obtained when xylose is processed in dilute solution at high temperature when a simple, single-pass reactor is used

without continuous removal of the furfural.

Hexoses, by a reaction analogous to the formation of furfural, are converted to hydroxymethylfurfural. At low temperatures, the yield of hydroxymethylfurfural from glucose is low but the yield increases very markedly with increase in temperature. Consecutively with its formation, hydroxymethylfurfural is converted to levulinic and formic acids. Levulinic acid has high stability under the conditions used for its production. High yield of levulinic acid is favored by carrying out the reaction at low temperature. Levulinic and formic acids are inevitable co-products if one wishes to make hydroxymethylfurfural, and all three are inevitable co-products when making sugar with dilute acid as a catalyst. The production of levulinic and formic acid can be accomplished in a one-step process without the prior isolation of sugar.

New information on the removal of hemicelluloses by means of dilute acidic solutions appeared in a paper (177) that dealt primarily with the problems of utilization of such hydrolyzates.

Recent reports (97, 98) have shown that glycerol can be manufactured by hydrogenolysis of purified wood sugars in yields equal to about 30 per cent of the sugar and at near competitive prices with present markets. Data on the kinetics of the reaction, separation methods, and costs are included.

Pulping

One of the important trends in the wood pulp field during the past 12 to 18 months is the increased interest in and production of cold soda pulps. The cold soda pulping process is suited especially to hardwoods for the production of pulps in yields of 85 to 92 per cent of the wood. These characteristics, coupled with pulp qualities suitable for use in such diverse products are corrugating board and printing papers, establish the economic importance of this pulp.

The cold soda process consists of treating wood chips with a solution of caustic soda at room temperature, or somewhat above, under atmospheric or hydrostatic pressure and then mechanically reducing the softened chips to pulp. Usually, the mechanical treatments include an initial coarse breakdown by means of a screw press or a disk mill followed by complete fiberization with a disk mill. The process is adaptable to either batch or continuous operation.

The 1957 production of cold soda pulp in the United States probably was about 50,000 tons. A reasonable estimate for 1959 appears to be 150,000 tons. It is understood that at present cold soda pulp is being made in two mills for corrugating board, in two mills for book papers (chiefly), in two mills for newsprint, and in one mill for molded pulp products. Mixtures of hardwood species are being used successfully in these operations.

An Australian mill is producing about 70 tons of cold soda pulp per day from eucalyptus for use in newsprint, and an Italian mill makes about 60 tons of this pulp per day for tissue. It is understood that a mill is being planned for Brazil.

The widely recognized need to use naturally occurring mixtures of species from the standpoint of both operational economy and good forest management has stimulated research toward this objective. This applies not only to mixtures of species within a wood class, but also to mixtures of classes—that is, hardwoods and softwoods. For example, at a mill in Michigan, aspen and jack pine are cooked together by the sulfate process in producing pulp for subsequent bleaching. Also, there is considerable interest in the sulfate pulping of oaks, because of the good bulking quality of this pulp type.

Continuous pulping installations are increasing in number, as is also the production of softwood chips at sawmills.

Two highly interesting developments in pulping with bisulfite were announced early in 1958. One of these is the Arbiso process, which uses sodium as the base (111), and the other is the Magnefite process, which uses magnesium as the base (381). Bisulfite cooking liquors differ markedly in composition from the conventional acid sulfite liquors in that they do not contain free sulfur dioxide and hence are less acidic, the respective pH values being about 4.5 and 1.5. The advantages of bisulfite pulping stems from this difference.

Composite major advantages attributed to these new processes in comparison with the standard acid sulfite process are: likely suitability to all woods, including mixtures of species; considerably faster rate of pulping without harm to pulp strength at temperatures as high as 180° C.; stronger and brighter pulps over the yield range of chemical and semichemical pulps; and simplification of pulping and recovery systems. Another bisulfite process, the two-stage Sivola process, consists of a primary digestion with sodium bisulfite and completion of cooking with sodium carbonate injected directly into the digester without interruption of the cooking. This process has been applied recently to Lake States hardwoods and to jack pine (306). In this study, a comparison was made of the two-stage pulps with kraft pulp, conventional, high free sulfur dioxide pulp, and high combined sulfur dioxide sulfite pulp. It was found that, with the two-stage process, pulps can be made comparable to kraft pulps in strength and comparable to conventional sulfite pulps in response to bleaching.

It thus appears that the bisulfite pulping technique is a means by which existing sulfite mills could bring into use species for which the conventional acid sulfite process is not suited and, in general, produce pulp of superior quality.

Developments in the Chemistry of Lignin

This review is a continuation of that included in last years "Review of Chemical Utilization", Irwin A. Pearl, FOREST PRODUCTS JOURNAL, Feb., 1958. It should be noted that the present review includes a substantial number of references to research reported in Russian journals that have just recently been abstracted. Some of these articles may be several years old. Articles in other journals missed in earlier reviews are also included.

Model Compound Studies: Studies on lignin model compounds have been continued in some areas of lignin research. Freudenberg and Schuhmacher (137) employed ultraviolet absorption curves for comparing synthetic and natural lignins with coniferyl alcohol and some of its dehydrogenation polymers. Aulin–Erdtman and co-workers (30) have extended their $\Delta\epsilon$ studies to include 22 more lignin model compounds, including dihydric phenols and hydroxybenzoic acids. Other model compound work was in the field of biosynthesis of lignin and/or radioactive tracer studies related to biosynthesis. Fuchs (140) reported on an improved procedure for synthesizing glucosides of *p*-hydroxycinnamyl alcohols in 99.5 per cent radioactive purity. Freudenberg and Niedercorn (136) incorporated phenylalanine (labeled at amino-bearing carbon) in young spruce stems and isolated active coniferin a few days later, which indicating that coniferin is an intermediate in lignin biosynthesis. These authors isolated lignin and compared its oxidation to isohemipinic acid with a DHP from radioactive coniferyl alcohol. Identical yields were obtained. In a somewhat similar investigation, Kratzyl and co-workers (244) implanted coniferin ($3\text{–}C^{14}$) into lignifying spruce tissue and subjected the powdered wood after extraction to ethanolysis. Vanilloyl methyl ketone ($3\text{–}C^{14}$) was isolated. These authors

oxidized the ethanolysis products to vanillin, vanillic acid, and oxalic acid, and compared specific molar radioactivities of the isolated pure compounds with the radioactivity of the incorporated coniferin to obtain the degree of dilution as a measure of the conversion of coniferin to the individual reactions.

Wacek and co-workers (164) added coniferin and other models to nonlignified spruce bark tissue and demonstrated lignification by means of the phloroglucinol reaction. Methoxyl contents increase to double that of control tissues without coniferin. The incorporation of coniferin was shown to require the action of living cells, and did not represent a nonspecific addition or polymerization. Similar lignification was shown with eugenol, but not with thymol nor propiovanillone glucoside.

Higuchi (191) in a histochemical investigation of β-glucosidase, phenol oxidase, and peroxidase, observed that in three species of bamboo shoots these enzymes are located generally around the portion showing a positive lignin reaction in the vascular bundles and suggested that this observation may explain the close relationship between these enzymes and lignification. All enzymes were highly active at the basal portion of the shoots, where lignification is in progress, which suggests participation of the three enzymes in lignification.

Freudenberg and co-workers (139) emphasize that enzymatic dehydrogenation of *p*-hydroxycinnamyl alcohols is the most important phase of lignin biosynthesis, and that laccase and peroxidase are the most important dehydrogenation enzymes. Similar dehydrogenation results could be obtained with oxygen in the presence of copper sulfate, but much more slowly. Aeration in the presence of copper sulfate transformed coniferyl alcohol to dehydrodiconiferyl alcohol, sinapyl alcohol to syringaresinol, and syringaresinol to dimethoxyquinone.

Schubert and Nord (352) reviewed the status of knowledge concerning the nature of lignin and the mechanism of lignification, and again suggest the tentative scheme comprising a photosynthetically derived carbohydrate, shikmic acid, *p*-hydroxyphenylpyruvic acid, and primary and secondary building stones as intermediates. Nord and coworkers continued their studies in the field of lignins and lignification. The wood-destroying fungus *Lentinus lepideus* was grown on two radioactive glucoses (6–C^{14} and 1–C^{14}) and the activities of both were incorporated into the formed methyl *p*-methoxycinnamate. The distribution of activity from the 6–C^{14} glucose indicates a synthesis route via shikimic and prephenic acids. In the other case, distribution of activity indicates some other route (365). Para-hydroxyphenylpyruvic acid (COOH C^{14}) was absorbed in the uppermost leaves of a mature sugarcane plant, and 15 days later the plant was cut down. The lignin isolated from the dried and powdered stalk was radioactive, indicating that *p*-hydroxyphenylpyruvic acid was an intermediate between shikimic acid and lignin building units (351). Alkaline nitrobenzene oxidation of the lignin gave nonradioactive vanillin, but alkaline fusion gave radioactive oxalic acid (2).

Traynard and Barnoud (383) prepared ethanol lignins from lilacwood and from cambial tissue cultures of lilac, and compared ultraviolet and infrared spectra of the two lignins. The tissue culture lignin absorbed at 270–275 mu, but did not show the characteristic minimum at 260 mu and maximum at 280 mu of the wood lignin. The infrared spectrum of the tissue culture lignin appeared to be intermediate between that of xylan and that of the wood lignin. These authors ran other experiments on hydrotropic lignins from poplarwood and from tissue cultures and compared products by spectrographic and chromatographic methods. They concluded that cambial tissue possesses a great power for isomerization and polymerization of carbohydrates, and is able to synthesize a lignin-polysaccharide complex of ill-defined nature.

Flaig and co-workers (16, 132, 133, 134, 16) have studied the formation of humic acid from models and from lignin, and concluded that humins are formed by condensation reaction between lignin-oxidation products and nitrogenous substances, notably ammonia, amino acids, and proteins.

Studies on Molecular Weights: McCarthy and co-workers have continued their studies on molecular weights of lignosulfonates. Studies were reported on delignification of hemlock, spruce, and maplewoods with sodium bisulfite-sulfurous acid at 135° (292). Degrees of delignification were determined for known conditions and average molecular weights for the lignosulfonates obtained were determined. From their results, these authors concluded that bonds between the structural units of the branched-chain lignin molecules are at least of two types, one easily hydrolyzable by acid, the other not. During delignification, lignin fractions of smaller molecular weight are removed first because the distribution of hydrolyzable linkages may be random, and the smaller segments (zeta-lignins) diffuse into the solution more rapidly than do the larger ones. Hydrolysis of the zeta-lignosulfonates continues in the aqueous medium, and results in a decrease in the molecular weight, which reaches its minimum when all hydrolyzable linkages have been hydrolyzed to provide an "omega-lignin". As delignification time increased, the resulting increase in molecular weight of lignosulfonates was probably due to irreversible condensation reactions, perhaps of the phenol-carbonyl type.

In further studies on delignification of hemlockwood at various acidities, Felicetta and McCarthy (131) found that about one-third of the lignin is removed by sodium bisulfite-sulfurous acid under weakly acidic conditions, but that stronger acid media are required for more complete lignin removal. The average molecular weight for lignosulfonates removed under weakly acidic conditions was about 3000, whereas those for pH's of 2.5 and 2.1 were 30,000 and 20,000, respectively. All lignosulfonate fractions decreased in molecular weight when heated with stronger mineral acid. Similar results were obtained with purified nondialyzable lignosulfonate fractions. Molecular weights decreased on further hydrolysis to a limiting value of 12,000.

Gross, Sarkanen and Schuerch (161) studied the molecular weight determination for a number of lignins and found that cryoscopy in ethylene carbonate offers a most convenient method.

Functional Groups in Lignin: Reactive groups in lignin have been given considerable attention during the past year. Kanda and Matsumoto (214) determined the amount of phenolic hydroxyl groups by Gustafsson's dinitroguaiacol method in the lignin of alkali pinewood pulps, and found that low-lignin pulps usually contained more phenolic hydroxyl groups than did pulps of higher lignin content. A large portion of these hydroxyls was found in the acetone-soluble material obtained from the unbleached pulps. Nikitin and Obolenskaya (291) determined carboxyl groups in soda and kraft lignins by esterification and saponification, and found a value of one carboxyl group per lignin molecule of 1200–1300 average molecular weight.

Lindgren and Mikawa (255) determined the cinnamyl alcohol groups in the lignin of sprucewood by a new color reaction that involves a transformation of these groups into *p*-dimethylaminoanilides of styryl-glyoxylonitriles, and found one cinnamyl alcohol group per 180 phenylpropane monomer units. Nakano (286) and coworkers have investigated the mechan-

ism of the Mäule reaction on hardwood lignin, and conclude that hardwood lignin reacts with dilute permanganate to form an oxidated lignin "A", which is further oxidized to oxidized lignin "B" by hydrochloric acid plus manganese dioxide. Subsequent treatment with ammonium hydroxide yields a purplish red coloration. The coloring material behaves like phenolphthalein towards acids and alkalis. The chlorine produced in the second step of the reaction is not required for color production. These authors attribute the reaction to the keto group in the alpha side-chain position.

From a number of reactions of alkali lignin, Nikitin (290) inferred that lignin has a keto-enol structure and determined the number of such groups in different preparations. Enol groups increased with heating in alkaline solution, as evidenced by greater hydrogen uptake under catalytic hydrogenation conditions. Polcin (319) investigated the removal of chlorine from chlorolignins and found that chlorine atoms in the side chains were very labile and easily removed. In a study of the effect of prehydrolysis on sulfonation of wood, Buyevskoi and Petropavlovskii (85) concluded that hemicellulose-free lignin is not converted into soluble lignosulfonates.

Aulin–Erdtman (29) reviewed the method for detecting changes in chromophoric groups and applied the procedure to the study of "Brauns' native lignins" from *Picea mariana, Picea abies,* and *Tsuga heterophylla* (31). Changes in ultraviolet absorption during methylation, catalytic hydrogenation, and sulfonation were compared with similar reactions of lignin-model compounds. Results indicated that the lignin preparations contained small proportions of phenolic residues of the coniferyl aldehyde, 4–ketoguaiacol, *o*-hydroxydiphenyl, and isoeugenol type as well as small amounts of etherified residues of the coniferyl aldehyde, 4–ketoguaiacol and isoeugenol type, along with large amounts of non-conjugated guaiacol residues. Derivatives of spruce lignin (*P.* abies) prepared under mild conditions generally showed a markedly lower phenolic content than did the "Brauns' native lignin" from the same species.

In a polarographic study of thiolignin and thioglycolic acid lignin, Kanda and Kawakami (213) were unable to obtain a reproducible polarographic wave height, and suggested that oxygen might denature the lignin on standing. Becherer and co-workers (46, 47) reported x-ray studies on cuprammonium lignin, lignin nitrate, and Scholler lignin, and concluded that lignin has an amorphous, tridimensional, branched-chain structure. From the analysis of the x-ray spectra of cuprammonium lignin, it was concluded that the basic unit of lignin contains a planar six-carbon ring. Two sharp absorption maxima at 1.4 and 2.5 Å. indicate the carbon-to-carbon distance to be 1.4 Å. around the ring and 2.4 and 2.8 Å. across the ring.

Elofson (120) determined the infrared spectra of humic acid preparations such as coal, peat, lignite, lignin and charred cellulose, and found substantial resemblance of all materials but with important differences. Theoretical significance of the absorption bands are discussed.

Alkaline Oxidation: Alkaline oxidation of lignin materials received continued attention. Kamaldina and coworkers (21) investigated the alkaline oxidation of lignosulfonates to form vanillin and studied the effects of time, temperature, reactant ratios, and oxidizing agents. Wawrzyniak (390) suggested removal of lignin prior to extraction of vanillin from acidified lignosulfonate-alkali oxidation mixtures. Button (84) investigated the oxidative cleavage of lignin sulfonates of both birch and maple with cupric oxide and with mercuric oxide, and found molar ratios of about 2:1 of syringyl to guaiacyl compounds in the identified products.

Tanaka and Kondo (378) oxidized beechwood with nitro-benzene and alkali and found the normal oxidation products usually found for hardwoods. From their results, these authors concluded that the guaiacyl portion of hardwood lignin consists of open, condensed, and diphenyl-type units similar to those of softwood lignin. Kratzl and Silbernagel (246) continued their studies on the effect of thermal treatment of wood and fiberboards on the alkaline nitrobenzene oxidation reaction. Several types of wood products were investigated. These included compressed woods, hard fiberboards, and technical acid lignin preparations. These materials were subjected to thermal pretreatment with moist heat and then subjected to alkaline nitrobenzene oxidation. In its chemical behavior, the lignin in the wood and fiberboard products was almost identical with the lignin of untreated wood, which indicates that the lignin condensation reaction did not seem to play a significant role in the production of modified wood and hard fiberboard. The acid lignins tested gave lower yields of vanillin than did Willstätter lignin, but after thermal pretreatment the yields of all decreased to essentially the same value. These authors concluded that the method of preparation of lignin has a pronounced effect on its chemical behavior.

Kratzl and Hofbauer (245) investigated the mechanism of the alkaline-vanillin cleavage of lignosulfonates by employing radioactive lignosulfonates. Coniferin labeled with radioactive carbon in both 2- and 3-positions, respectively, was infused into spruce branches to induce enzymatic polymerization. The extracted wood was milled, subjected to acid sulfite digestion, and the solution remaining after removal of cellulose was hydrolyzed with excess alkali. The alkaline residue showed the presence of radioactive vanillin and inactive acetaldehyde in the coniferin-3-C^{14} experiment, and inactive vanillin and radioactive acetaldehyde in the conifierin-2-C^{14} experiment. These results prove that the cinnamyl alcohol side chain is oxidized in the living tree to the corresponding aldehyde, and hence becomes accessible after sulfonation for reverse aldol cleavage. The two cleavage products, vanillin and acetaldehyle, originate from the same phenylpropane system (polymeric coniferylaldehyde hydrosulfonic acid).

Pulping and Hydrogenation: Studies were continued on the mechanism of pulping reactions. Gierer and Alfredsson (151) studied the sulfidizing reaction of lignin by means of model compounds of the *p*-hydroxybenzyl alcohol, akyl ether, and dibenzyl ether type along with isolated lignin and thiolignin preparations and finely ground wood powders. The model compounds react readily with sodium hydrosulfide solutions at 100° to yield corresponding sulfides unless β-position substitution causes steric hindrance. Para-hydroxybenzyl alcohols and alkyl ethers react with ethyl mercaptan to yield *p*-hydroxybenzyl ethyl sulfides. The major portion of sulfur in the various thiolignin preparations was found to be acid-labile, and these authors concluded that the principal building units were benzylsulfidic in nature. Acid cleavage of model sulfur compounds was reported in another paper (152).

Arlt, Gross and Schuerch (26) studied the lignin fraction obtained by hydrogenation pulping of maple wood. These investigators compared fractions obtained by chromatography and countercurrent extraction with hydrogenated lignin monomers under the same conditions and found two previously unreported phenolic monomers in the lignin fraction. Granquist (157) rehydrogenated a lignin obtained by alkaline hydrogenation pulping of Douglas-fir and, oxidized the product with nitric acid. Dimethylmalonic acid was found along with many unidentified acids be-

lieved to be higher homologs. Substances related to thujic acid were postulated.

Sakakibara and co-workers (374) hydrogenated spent sulfite liquor and saccharified wood residue by reaction with sodium hydroxide and ethanol under pressure, and obtained much higher yields of ether-soluble oils than by conventional catalytic hydrogenation. Chudakov and Sukhanovskii (94) degraded hydrolysis lignin by first mixing it with alkalies, catalysts and sufficient water, extruding it in fine filaments, drying it, and subjecting it to thermal treatment mixed with petrolatum at various temperatures to obtain either protocatechuic acid or oxalic acid as chief products. Panasyuk (302) increased yields of phenols from cotton-hull hydrolysis lignin by vacuum thermal treatment in the liquid phase instead of dry distillation. Active carbon was obtained as a by-product. Modifications of the process and theoretical considerations are discussed in a series of papers (303).

Chudakov and co-workers (369) acidified alkali-activated hydrolysis lignin to yield "lignin acids" of very high surface area and with ability to react with divalent and trivalent metals. Lead, aluminum, and barium were precipitated quantitatively from their salt solutions. Other metals were precipitated to various degrees. Kuriyama (248) pyrolyzed lignin and found that the greatest degradation occurs between 310 and 400°, and thermal decomposition is finished at 500°. Schobinger (349) studied the conversion of wheat-straw lignin during retting by means of infrared light and by periodic analysis for sulfuric acid lignin, milled wood lignin, chlorite holocellulose, hemicellulose, and alpha-cellulose.

Lignin Analysis: Analytical procedures for lignin and lignin materials have been given considerable attention. Kratzl (243) reported a number of microanalytical methods suitable for determining the similarity of a material to native lignin. These methods include botanical staining, color reactions, infrared and ultraviolet absorption, oxidative degradation to aromatic aldehydes, ethanolysis to the four Hibbert building units, and possibly sulfonation and fission of the resulting lignosulfonic acid to vanillin and acetaldehyde. This author points out again that earlier criteria, such as insolubility in acids and methoxyl content, are not adequate for lignin determination.

A new quantitative procedure for the determination of lignin in vegetable tissue has ben reported by Popov (300). The procedure involves reaction with a solution of zinc chloride in hydrochloric acid at 45°, dilution, boiling and filtering. The lignin in reeds has been determined by the Kürschner-Schweitzpaherova method, which consists of hydrolysis of methoxyl groups with 82 per cent sulfuric acid at 201°, oxidation of the methanol formed by means of alkaline potassium permanganate, and back titration of excess permanganate (366). Hedlund and Wilson (186) determined spent sulfite liquor in lakes and rivers by ultraviolet absorption measurements.

Ganczarczyk (145) investigated the nitrosolignin procedure of Pearl and Benson for determining lignin materials in spent sulfite liquor, liquor concentrates, and isolated lignosulfonate preparations. The colored compounds formed showed maximum absorption at 4700 Å. This author concluded that the procedure was well-suited for the simple and rapid determination of lignosulfonates in the concentration range of 0.1–3.0 ml. per liter. Similar studies were made with the Folin–Denis phosphomolybdate-tungstate colorimetic method, and procedures for determining lignosulfonates in mill effluents are reported (144).

Kleinert and Dlouhy (227) have described in iodic wet-combustion method for the determination of the lignin content of Klason lignin residues or of lignosulfonates. Kleinert and Joyce (225) continued their studies on the short wavelength ultraviolet absorption of lignin and reported on use of the procedure for control in kraft cooking and brown stock washing (224, 226). A new method for the determination of lignosulfonates in tanning liquors by precipitation with cinchonine was reported by Hallet (170). Arendt and Schenck (25) employed the nitrobenzene-alkali oxidation for detection of lignin materials in phenolic moldings and aminoplasts.

Lignin Isolation: Studies have continued in the field of lignin isolation. Bland (65) extracted *Eucalyptus regnans* with methanol at 150° and analyzed the product by two-dimensional paper chromatography. He found three lignin components and a number of monomolecular compounds including vanillin, syringaldehyde, and sinapaldehyde. Fukuzumi and Shibamoto (141) pretreated *Picea jezoensis* with hydrochloric acid and, after neutralization, extracted with acetone-water under hot and cold conditions. They obtained materials that gave ultraviolet and infrared spectra similar to those of Brauns' lignin. Lyness and Schenker (261) extracted slash pinewood with water and obtained a lignin preparation essentially identical with Brauns' lignin.

Panasyuk and co-workers (305) compared hydrolysis lignin from cotton hulls with lignin from unhydrolyzed hulls, and found that the hydrolysis lignin contained much less methoxyl and yielded much less aldehydes on nitrobenzene oxidation. Snyder (371) describes a lignin by-product obtained in a process for producing sugars from wood. The process consists of impregnation with alkali and subjecting to steam at 600–1250 psi. Bader (32) found lignin in marine sediments, but concluded that lignin in these sediments probably originated from the land. Hata and Sogo (180) studied the bark lignin of *Pinus densiflora* and compared it and its fractions with the lignin of the wood and inner bark of the same species. Similarities and dissimilarities are pointed out.

Buzagh and Tar (86) peptized with sodium hydroxide the lignin preparations obtained by extraction of rye straw, sprucewood, and peat with alcoholic sodium hydroxide and dioxane, and characterized the soluble portions. Furman and Watt (143) describe a pulping process that employs a halogenated saturated aliphatic aldehyde such as 2, β-dichloropropionaldehyde, and that yields a chemically unchanged lignin.

Fractionation of lignosulfonates from spent sulfite liquors has been reported. Harris and Hogan (176) fractionated lignosulfonates from both aspen and spruce spent liquors by means of long-chain amines and characterized the fractions by means of a chromatographic-ultraviolet absorption technique. Gray and Crosby (160) produced a high-molecular-weight sugar-free lignosulfonate by fractional precipitation of spent sulfite liquor with lime and decationizing the product with an ion-exchange resin. Van Blaricom and Gray (385) isolated low-molecular-weight lignosulfonates from spent liquor by adsorption on tertiary-amine type anion-exchange resins. Further fractionation of lignosulfonates on phenolic ion-exchange resins was reported (386). In the last case, fractionation appears to be due to molecular adsorption rather than ion-exchange. Jantzen (206) separated high and low molecular weight lignosulfonic acids from each other and from spent sulfite liquor by contacting with chrome-tanned hide.

Lignin Utilization: Many articles and patents have appeared on the utilization of lignin materials. Giesen (153) reported a two-stage process for recovery of lignin from black liquors by carbonation, and Ball (36) described a freezing process for coagulation of lignin particles in acidified

black liquor mixtures. Doughty (112) has increased the acetone solubility of alkali lignin by heating it in aqueous alkali at 140–250° Lignosulfonates have been precipitated from spent liquors by metallic hydroxides other than lime (70), and by electrolysis in alkaline solution (331). Lignosulfonate fractions have been isolated as by-products in the reactive solvent method for removing sugars from spent sulfite liquors (259). Modified lignosulfonates have been obtained by heating in the presence of ammonia or more of its derivatives (185), and modified lignin materials have been produced by refluxing alkaline solutions of either alkali lignins or lignosulfonates with acrylonitrile (388).

Improvements in the production of vanillin from spent sulfite liquor have been published and patented (343, 380), and vanillin and lignin have been converted to protocatechuic acid, which in turn has been processed to yield linear polyesters suitable for fiber production (15, 68). Oxalic acid has been prepared from hydrolysis lignin by oxidation with nitric acid (241). The commercial production of dimethyl sulfide from kraft black liquor has been described in detail (184, 271), and improvements in the process have been patented (95, 96, 165). Processes for the production of dimethylsulfoxide from dimethyl sulfide have been described (1).

Synthetic resins have been prepared from alkali lignin by condensation with acetylene (289) and by condensation with phenol (93). Low-grade resins were prepared from desulfonated lignin by treatment with sulfuric acid (376). Thermosetting resins and binders were prepared from spent sulfite liquor by condensing with phenol and an aldehyde (265, 266) and by heating with ammonia (155). Ligninfilled paper has been prepared for laminated plastics use (135). Molding compositions have been produced from lignin materials by heating with sodium or calcium hydroxides (72).

Considerable attention has been given to utilization schemes based upon the physicochemical properties of lignin materials. Browning (80) has studied the colloidal properties of lignosulfonate solution by rheological measurements, and has shown that rheological properties of lignosulfonate solutions can be controlled and modified by means of electrolytes. A number of well-drilling and well-cementing compositions containing lignosulfonates (79, 81, 276, 277, 339, 379) and alkali lignins (269, 270) have been described. Lignosulfonates have again been used in ceramic mixes (42, 76, 154), and alkali lignin has been employed in the production of waterproof concrete (83). The surface-active properties of lignosulfonates have been utilized in a sprayable fungicidal and insecticidal composition (77) and as a dispersing agent for carbon black in aqueous media (353). Alkali lignins have been employed as fillers and compounding agents in both natural and synthetic rubbers (182, 323, 340). In addition, lignins activated by alkali (375) and by reaction with formaldehyde (189) have been used for rubber compounding. Lignosulfonates and alkali lignins have been processed and modified to give better tanning agents (4, 106, 118, 166, 218, 256). Other uses reported for lignosulfonates include electroplating baths for copper (300), pickling composition for metals (318), dust control (175), for the preparation of ion-exchange resins (230), and for the sequestering of metals in the treatment of hard water (69).

Ali and co-workers (10) found that a lignin acetic acid obtained from black liquor was a promising fungicide for the control of four jute-destroying parasites. Lynch and Lynch (260) studied the resistance of protein-lignin complexes to soil micro-organisms and found that combination with lignin attenuated microbial attack of proteins. McKnight and Mason (263) reported on the spruce periodate lignin sorption of the vapors of water, methanol, and ethanol in large amount and vapors of benzene and nitrogen in small amount.

A number of reviews have appeared during the past year covering the chemical utilization of lignin (63, 183, 308, 309, 310, 311, 322, 393).

Wood Extractives

Although extractives are normally only minor constituents of trees, an increasing amount of interest is being shown in them. Not only are they of considerable importance in understanding the biochemistry and taxonomy of trees, but they also contribute to many of the properties of wood such as its odor, color, light stability, hazards to health, decay and insect resistance, strength properties, density, flammability, hygroscopicity, permeability, ease of pulping, paintability, effect of setting of concrete, and so forth. Finally there is the fact that many extractives ranging from tannins to alkaloids are of considerable commercial value. The marketing of extractive compounds such as quercetin and γ-conidendrin derived from wood wastes represents, perhaps, one of the most rewarding aspects of extractive research.

Knowledge on the composition of the extractives of most woods is very small. In view of the increasing interest in extractives, and to stimulate further research in this field,a thorough literature survey of the annual progress in extractive research is being initiated in this review. Reports on wood extractives for both 1957 and 1958 are included this year, and next year it is planned to broaden the survey to include bark extractives. It is hoped that this survey will help to fill a serious gap in the literature. Too often new compounds found in wood and bark are indexed in chemical journals under the name of the compound, but not under the species in which it is found. Although abstracts are published by several organizations, publications on extractives are often difficult and sometimes impossible, to locate. It is hoped that this survey will help to remedy this situation.

Although most reports have dealt with a single species, some excellent reviews and surveys have appeared. The staff of The Institute of Paper Chemistry has done an excellent job in updating their 12-year old review, "Extraneous Components of American Pulpwoods" (202). The monomeric aromatic aldehydes, ketones and acids related to lignin have been the subject of considerable investigation. Janek has investigated *Nyssa sylvatica* (172), while the Japanese have investigated the sodium hydroxide extracts of 19 woods (287). Pearl and others have done a tremendous amount of work in this field; they have investigated several dozen species (312). The most interesting result is the occurrence of *p*-hydroxybenzoic acid in *Populus* and *Salix* spp., sometimes in remarkably large amounts. The distribution of shikimic acid in the wood, bark, leaves, and so forth, of a number of trees has been studied in relation to lignin formation (178). Wood, bark, and leaves, of a large number of species including many trees have been analyzed for resin content by extraction with acetone, and for rubber content by subsequent extraction with benzene (272). The distribution of eleven simple sugars in the outer and inner bark, sapwood and heartwood for a series of softwoods has been studied recently (370), and a similar study of the simple sugars in the inner bark and sapwood of ash, aspen, and birch has also been made (327). The general role of extractives in wood has been discussed (288).

In the pines, most of the research has been related to rosin. A symposium on naval stores was held in 1957, and at the same meeting the isolation of a new resin alcohol, elliotinol, from slash pine was reported (332). The resin acids derived from gum rosin (mostly longleaf and slash pine in the United States and Scotch pine in Europe), wood rosin and tall oil have been the subject of many publications

(34). Particularly noteworthy is the analysis of resin acids by their infrared spectra (82). Abietene has been isolated from jeffrey pine (199). The oleoresin from Japanese red pine is rich in oily sesquiterpenoids, which lower the softening point of the rosin (39), and analysis of this rosin has also shown that traces of abietic-type diterpenoid aldehydes were present (24). Dr. N. T. Mirov is currently writing a book on the turpentines of the genus *Pinus* and has recently published some of his data (273).

The fatty acids of pinewood and tall oil have been further investigated (211), and a branched-chain fatty acid has been obtained from *P. radiata* (173). The arabogalactan from jack pine has been studied (61), and a lignin-like material extracted with hot water from slash pine has been investigated (261). The heartwood extracts of maritime (91) and eastern white pine have been examined, and the structures of cryptostrobin and strobopinin have been clarified by synthesis (268). On the basis of a survey, it has been claimed that a taxonomic difference between *Pinus* spp. and *Abies* spp. is that flavanonols occur only in the former (301).

The lignans in firwood have been thoroughly studied by Freudenberg via countercurrent distribution through 3,000 tubes (138). Spectrochemical analysis of *Abies grandis* wood and bark has been the subject of a thesis (119).

The extractives of Sitka sprucewood have been investigated (231). One-half of the ether extract consisted of the very interesting and unusual ester of optically active 2-octanol plus β-sitosterol with phthalic acid. The flavonoids in larchwood have been studied (187, 283); the oleoresin of *Larix kaempferi* has been investigated (394); and the water-soluble ε-galactan of *Larix decidua* has been shown to be a highly branched arabogalactan (28). The galactan from western larch is currently being studied at Montana State University. The heartwood extracts of *Picea glauca* and *P. engelmannii* have been studied (39). The polysaccharides extracted by cold water from *P. glauca* wood have also been investigated (3). Freudenberg has studied the lignans in *P. abies* (138), and the lignins extracted by neutral solvents have also been investigated (62).

The simple sugars in sprucewood are discussed by Sandermann and the deleterious effect of xylose on cements and compressed board noted (342). Spruce resin and its effect on the properties of the wood have also been studied (110). Kahila has investigated the variation of spruce ether extracts with time, as well as the composition of the oleoresin (209).

In the family Cupressaceae, a number of species have been studied. *Juniperus communis* oil was shown to contain a series of sesquiterpenoids including juniper camphor (280), a new alcohol, junenol (279), and α- and δ-cadinol (281). All of their structures were elucidated. Ferruginol, 9-ketoferruginol, and Δ 9-dehydroferruginol are found in the wood, but no cedrene or cedrol, a finding that may be characteristic of the section oxycedrus (73). The formation of xanthoperol during hydrolysis is also discussed.

The excellent work of Zavarin and Anderson at the California Forest Products Laboratory on incense cedar heartwood (*Libocedrus decurrens*) has produced a detailed knowledge of the heartwood composition, plus the discovery of new compounds and their synthesis, and finally an understanding of the possible causes for the loss of decay resistance of the central section of the heartwood (399). Western red cedar (*Thuja plicata*) heartwood has been the subject of another thorough investigation by the Canadian Forest Products Laboratory. Besides the previously reported α, β, and γ thujaplicins, two new thujaplicins have been found. Other heartwood constitutents have been investigated, and especially the lignan, plicatic acid (147). The pattern of decay resistance due to the thujaplicins has also been further studied (347).

Erdtman at the Swedish Forest Products Laboratory has extended his survey of softwood heartwood extractives to *Chamaecyparis nootkatensis,* in which a new sesquiterpene, nootkatene, is found (126); *Cupressus sempervirens* (124); *Widdringtonia, Callitris* and *Austrocedrus spp.* (125). A report on *Libocedrus formosana* extractives has also appeared (258). The essential oil from the wood of *Biota orientalis (Thuja orientalis)* (192) and *Thujopsis dolabrata* (192, 293) has been investigated by the Japanese. The sesquiterpene present in these two species, widdrene, is shown to be identical to thujopsene, and also occurs in several related species (125). Its structure has been investigated (8). A new tropolone found in *Thujopsis dolabrata* is identical to that found in *Thuja plicata* (147).

The heartwood of *Cotinus coggygria (Rhus cotinus)* has been found to contain the hydroxyaurone, sulphuretin, as well as fustin and a gallic acid methyl ester (223). The absolute configuration of the lignan, guaiaretic acid, from the heartwood of *Guaiacum officinale* has been determined and the presence of the mesodihydro derivative shown (342). The glucosidic lactone of 4-0-methylgallic acid, bergenin, has been found in the heartwood of *Shorea leprosula* as well as the bark of *Corylopsis spicata,* and has been shown to be identical with vakerin from *Caesalpinia digyna* (87). The heartwood of rosewood *(Dalbergia sissoo)* has been found to contain dalbergin and O-methyldalbergin, the first time 4-phenylcoumarins have been found in nature, and their structure has been confirmed by synthesis (5).

The heartwood of *Artocarpus integrifolia* has also been investigated (105). In *Podocarpus* spp., the structure of the diterpenoid phenol, totarol, found in *P. totara* has been proven by synthesis (37). *P. ferrugineus* has been found to contain the similar dehydroferruginol, which is also found in the closely related species, *Dacrydium cupressinum* (73). The heartwood extractives of *P. spicatus* have also been studied (74).

Largely due to the efforts of the group at The Institute of Paper Chemistry, considerable new information has been obtained on the biochemistry and constituents of aspenwood (327, 377). The main constituent of aspenwood extracts is *p*-hydroxybenzoic acid, which can be obtained in a very pure condition (285). Syringaresinol, lirioresinol, and another isomeric tetrahydro-1, 4-bis (4-hydroxy-3,5-dimethoxyphenyl) furol[3,4-c] furan have been isolated from aspen sulfite liquors (313). Also of interest is that the buds of *Populus balsamifera (P. tacamahaca)* contain two sesquiterpene alcohols active against the tuberculosis bacilli (116).

Many interesting developments in the field of flavonoid chemistry have been reported. The biogenesis of flavonoids has been studied by Hergert and Goldschmidt (187). The distribution of a quercetin, dihydroquercetin (taxifolin), and their 3'-β-glucosides in the wood, bark, and needles of Douglas-fir and many other softwoods were determined. Hancock (172) has also worked along these lines. He has found that the major extractive of the inner bark of Douglas-fir is a leucoanthocyanidin, and has analyzed its distribution in the bark and wood along with that of dihydroquercetin. The quantitative analysis of dihydroquercetin in several woods has been discussed by Barton and Gardner (40), and the absolute configuration (99) and polarographic behavior (283) of this compound has been determined. Atlas cedarwood has been found to contain dihydroquercetin and its 3'-glucoside (187).

A thorough survey of the flavonoids and glycosides of *Prunus* spp. wood has been carried out, and several new

compounds have been reported. Naringenin, aromadendrin and their glycosides are especially common, although almost two dozen other flavonoid derivatives have been found (179). A new flavanonol has also been found in *Salix hultenii* heartwood (174). From the heartwood of *Morus lactea* has been isolated the first naturally occurring 2'-hydroxydihydroflavanol, dihydromorin, as well as traces of dihydrokaempferol (342). Since air oxidation converts dihydromorin into morin, the possibility exists that the morin reported in *Chlorophora tinctoria, Artocarpus integrifolia, Maclura pomifera,* and *Morus* spp. and so forth, may actually be present in the wood as the dihydro derivative.

A new leucoanthocyanidin, gleditsin, has been found in the heartwood of *Gleditsia japonica* together with fisetin and fustin (dihydrofisetin). This is identical to mollisacacidin found in the heartwood of black wattle *(Acacia mollisima)* (100, 391), and can be formed by reduction of fustin. Pinitol and a sterol were also isolated (219). *A. catechu* heartwood has been found to contain a phlobatannin similar to a catechin autoxidation polymer as well as fisetin, quercetin, guercetagetin and rutin (181). The quebracho extracts from *Schinopsis* spp. have received considerable attention, especially in regard to the role of (−) leucofisetinidin, an enantiomorph of mollisacacidin, as a possible precursor of the condensed tannins (233a, 336, 391). The structures of the leucoanthocyanidins, peltogynol A and B, found in the heartwood of *Peltogyne* spp. have also been elucidated (89).

Several coloring matters have also been investigated. The color precursor in western hemlockwood is believed to be some sort of a polymeric flavandiol (239). The structure of the physiologically active yellow coloring matter, found in the bark and other parts of the mangosteen tree has been determined (396), and the structure of the yellow pyranoxanthone, jacareubin, from the heartwood of *Calophyllum brasiliense* has been elucidated by King and others (220). Mangiferin, the coloring matter of *Mangifera indica,* has been shown to be a xanthose glucoside (201).

Two highly unusual new flavonoids, keyakinol and keyakinin, have been found responsible for the resistance of *Zelkova serrata* wood to decay by wood-rotting fungi (142). In this case, a sugar residue is combined with the flavonoid ring system, not through a glycosidic linkage, but through a direct carbon-to-carbon linkage. The same unusual situation has been found in the flavonoid pigments of *Vitex* spp., vitexin and homovitexin (128). The antifungal tetrahydroxystilbene previously reported in osage orange (38) has now been found also in *Neratrum grandiflorum, Artocarpus lakoocha* wood (275), and *Morus bombycis* heartwood (233), and may be identical to the cudranin found in *Cudrania triloba.* The same authors also investigated the heartwoods of *Platycarya strobilacea* and *Machilus thunbergii* and found ellagic and gallic acids plus some sugars in the former, and lignoceric acid, quercetin, *d, l*-catechol, and some sugars in the latter.

The fungal resistance of some oak heartwoods has been attributed to the presence of tartaric acid (57). The insecticide present in many parts of the mamey tree *(Mammea americana)* is under study by Djerassi (109). From black locustwood has been isolated the antibiotic, trans-Δ^2-hexenol (348), as well as tannin from both the wood and bark (207).

Sandermann has shown that the poor drying of polyester lacquers on *Chlorophora excelsa* was due to the stilbene, chlorophorin, while on *Dalbergia nigra,* it is due to a phenol (342). He has also studied the termite resistance of woods and shown that the active compounds are usually stilbenes, quinones, or pyran compounds. A methyl or methoxyl group in the 2-position of anthraquinones was especially effective in increasing the toxicity. The resistant species studied include *Paratecoma peroba, Stereospermum suavelolens, Tabebuia flavescens* and *ipe, Diospyros* spp., *Chlorophora tinctoria, Pterocarpus soyauxxi, Vitex* spp., *Tectona grandis,* and *Guaiacum officinale.* Among the active components were found tectoquinone, lapachol, pterostilbene and lapachonone (342).

Concerning the resistance of teak heartwood *(Tectona grandis),* it has been recently shown that the large amount of techtoquinone present (307) is not the only factor that contributes to termite and fungal resistance (338). Other compounds that have recently been identified in teak heartwoods include the triterpenoid, betulinic acid (6), as well as 3-hydroxytectoquinone (307) and *o*-cresyl methyl ether (107).

Several interesting triterpenoids have been reported. Dammar resin from *Dipterocarpus* spp. has been shown to contain a new type of triterpenoid with an unrearranged skeleton, hydroxyhopanone (346). A symposium at the University of Glasgow in July 1957, entitled "Recent Advances in the Chemistry of Terpenoid Compounds" had papers on the constitution of the sesquiterpenoid gurjunenes that accompany the triterpenoids in dammar resin as well as a paper on a new triterpenoid katonic acid from the heartwood of *Sandoricum indicum.* A new triterpenoid emolic acid, was isolated from the wood of *Emmenosperma alphitonoides* wood together with an essential oil and a saponin also found in the bark (71).

Eucalyptus spp. have come in for an increasing amount of attention. The structure of the unusual triterpenoid, cycloeucalenol, from tallowwood has been elucidated (103). The fungicidal principle of tallowwood and silvertop ash is found in the methanol extracts, and is now being further investigated (337). *E. pilularis* gum has been shown to contain (+)-leucodelphinidin (146). A number of compounds have been isolated from eucalypt resins, including an antibiotic, citriodorol, from *E. citriodora* (344)

Phytosterols and triterpenes have been reported in *Atalaya hemiglauca* (149), *Teclea grandis* bark (149), *Zanthoxylum rhetsa* (163), the saponin from *Zizyphus joazeiro* (23), *Flindersia* spp. bark (60), *Mitragyna ciliata* wood (221), *Vitex* spp. heartwood (128), and insect-infected *Acer negundo* wood (232). The composition and variation of the ether extract of birchwood has been studied, and a new sterol is reported (210). A new 12-ketosapogenin, willagenin, has been isolated from the saponin present in *Yucca filifera* sawdust (217). *Rhus trichocarpa* wood has found to contain sitosteryl-β-D-glucoside, fisetin, fustin, gallic acid, sugars and pigments (174).

Several gums have ben studied, including those from *Brachychiton diversifolium* (193), *Anogeissus latifolia* (193), *Fagara xanthoxyloides* (382), *Sterculia urens* (326), and *Acacia* spp. (282). Cativo gum, the oleoresin of *Prioria copaifera,* has been found to consist mainly of an unusual new bicyclic unsaturated resin acid, cativic acid, and its corresponding ester, cativyl cativate (400). The terpenoid isolated from *Zieria smithii* has been shown to possess the unusual strained a-pinenone structure (64). Tigaso and terentang oil from *Campnosperma* spp. have been found to contain highly unusual unsaturated and cyclized fatty derivatives (104).

Alkaloids have been investigated in *Stemmadenia* spp. wood and bark (389), *Flindersia* spp. wood and bark (60), and *Taxus baccata* (156). The wood and bark of South American rosewood trees (*Aniba* spp). has been shown to contain a variety of interesting compounds, including the alkaloid anibine, the unusual α-pyrone 4-methoxyparactoin, phenylcoumalin and

par. otoin as well as cotoin and pinocem in (278).

The production of tannin from domestic sumac has been the subject of USDA bulletin (43). Chestnut wood are being used as the source of a commercial tannin preparation, "Dr ", for use in oil-well drilling fluid (150).

Literature Cited

1. badie-Maumert, F. A. 1957. Paterie 79: 519.
2. cerbo, S. N., W. J. Schubert, and F. Nord. 1958. J. Am. Chem. Soc. 80: 1990.
3. dams, C. A. 1957–1958. Tappi 40: 21; 1958. Can. J. Chem. 36: 755.
4. dler, E., and E. K. M. Hägglund. 1957 Can. Patent 548,504 (Nov. 5).
5. Ahluwalia, V. K., and T. R. Seshadri. 1957. J. Chem. Soc.: 970; Ahluwalia, V. K., A. C. Mehta, and T. R. Seshadri. 1957. Proc. Indian Acad. Sci. 45A: 15.
6. Ahluwalia, V. K., and T. R. Seshadri. 1957. J. Sci. Ind. Research (India) 16B: 323.
7. Ahluwalia, V. K., and T. R. Seshadri. 1957. J. Sci. Ind. Research (India) 16B: 373.
8. Akiyoshi, S., and S. Nagahama. 1957. Bull. Chem. Soc. Japan 30: 886.
9. Alexa, G., C. Strub, I. Iarosinchi-Drabic, and C. Maga. 1956. Rev. Chim., Acad. rep. populaire Romaine 1(2): 115–36.
10. Ali, M. I., Q. A. Ahmed, and M. H. Khundkar. 1958. Pakistan J. Sci. Ind. Research 1: 79.
11. Altman, R. F. A. 1956. Bol. tec. inst. agron. notre, No. 31: III–3.
12. Anderson, A. B. 1957. Composite Wood (India) 4: 56–72.
13. Anderson, H., and A. Bilkens. 1958. Australian J. Appl. Sci. 9(2): 184–91.
14. Anon. 1957. Chemical composition and uses of bark. USDA Forest Service, Forest Products Lab. Rept. No. 1666–5: 10 p. (March).
15. Anon. 1957. Chemurgic Digest 16: 10.
16. Anon. 1957. Pulp & Paper 32(8): 100, 160–1.
17. Anon. 1958. Chem. Eng. News 36 (7): 58 (Feb. 17).
18. Anon. 1958. Chem. & Ind. No. 45: 1465–8 (Nov. 8).
19. Anon. 1958. Noeast. Logger 6(7): 8, 40.
20. Anon. 1958. Noeast. Logger 7(4): 30–1.
21. Anon. 1958. Western Logger and Lumberman, No. 142 (Oct.).
22. Anon. 1958. Wood and Wood Prod. 63(8): 22–3, 70, 72.
23. Antonaccio, L. D. 1957. Rev. quim. ind. (Rio de Janeiro) 26: 129.
24. Ant-Wuorinen, O., and E. Lehtinen. 1957. Paperi ja Puu 39(4a): 151–64, 183.
25. Arendt, I., and H. Schenck. 1958. Kunstoffe 48: 23.
26. Arlt, H. G. Jr., S. K. Gross, and C. Schuerch. 1958. Tappi 41: 64–70.
27. Arlt, H. G., Jr., S. K. Gross, and C. Schuerch. 1958. Tappi 41: 64–70.
28. Aspinall, H., and J. Ramstad. 1958. J. Chem. Soc.: 593, 1059.
29. Aulin-Erdtman, G. 1958. Svensk Kem. Tidskr. 70: 145.
30. Aulin-Erdtman, G., and L. Hegbom. 1957. Svensk Papperstidn. 60: 671.
31. Aulin-Erdtman, G., and L. Hegbom. 1958. Svensk Papperstidn 61: 187.
32. Bader, R. C. 1956. Deep-Sea Research 4: 15.
33. Balandin, A. A., N. A. Vasyunina, G. S. Barysheva, and S. V. Shepigo. 1957. Izvest. Akad. Nauk, USSR: 392; C. A. 51: 14260.
34. Baldwin, D. E., V. M. Loeblich, and R. V. Lawrence. 1958. J. Org. Chem. 23: 25; Baldwin, D. E. V. M. Loeblich, and R. V. Lawrence. 1958. Ibid. 23: 25; Royals, E. E., W. C. Bailey, and R. W. Kennedy. 1956. ibid. 23: 151; Kajanne, P., and E. Honkanen. 1957. Paper and Timber 39: 171; Grover and Seshadri. Tetrahedron, to be published; McKelvey, J. B., N. C. McConnell, N. M. Johe, and R. V. Lawrence. 1957. Paint, Oil, Chem. Rev. 120(14); 10; Braun, J. C., and E. L. Patton. 1957. Forest Prods. J. 7: 338; Bardyshev, I, I., and V. V. Kohomskaya. 1958. Zhur. Obshchei Khim. 28: 538; Bardyshev, I. I., V. V. Kohomskaya, and Uhova. 1957. Dokl. Akad. Nauk. SSSR 112: 653; Bardyshev, I. I., A. C. Sokolov, and O. I. Chernyaeva. 1958. Zhur. Priklad. Khim. 31: 609; Wenkert, E. 1958. J. Am. Chem. Soc. 80: 217; Wenkert, E., and J. W. Chamberlin. 1958. ibid. 80; 2912; Green, B., A. Harris, and W. B. Whalley. 1958. Chem. & Ind.: 1084; Edwards and Howe. 1958. ibid. 629; Bruun, H. H. 1957. Acta. Chem. Scand. 11: 907; Krohnstad, W. 1957. Norsk Skogind.: 186; Rotovic, B., S. Dugandzic, and M. Dugandzic. 1957. Hemisko Drustvo. Glasnik 22(3): 181.
35. Balenkii, S. I. 1957. Gidroliz i. Lesokhim. Prom. 10(1): 17–20; C. A. 51: 11712.
36. Ball, F. J. 1957. U. S. Patent 2,802,815 (Aug. 13).
37. Barltrop, J. A., and N. A. J. Rogers. 1957. Chem. & Ind.: 397.
38. Barnes, R. A., and N. N. Gerber. 1955. J. Am. Chem. Soc. 77: 3259.
39. Barton, G. M., and J. A. F. Gardner. 1957. For. Chron. 33: 136.
40. Barton, G. M., and J. A. F. Gardner. 1958. Anal. Chem. 30: 279.
41. Battersby, A. R., and H. F. Hodson. 1958. Proc. of Chem. Soc.: 287–9.
42. Bauer, W. H. 1958. U. S. Patent 2,833,659 (May 6).
43. Bear, J. E., and A. F. Sievers. 1957. Sumac, its collection and culture as a source of tannin. Production Research Report No. 8, Agricultural Research Service, U. S. Dept. Agriculture.
44. Beazley, R. 1958. Noeast. Logger 6 (8): 34–7, 46, 53.
45. Beazley, R. 1958. Noeast. Logger 6(8): 38.
46. Becherer, G., E. Höhne, and G. Voightlaender-Tetzner. 1955. Naturwiss. 42: 578.
47. Becherer, G., and G. Voightlaender-Tetzner. 1955. Naturwiss. 42: 577.
48. Becker, E. S. (Oregon State College) University Microfilms (Ann Arbor, Mich.), Publ. No. 24,625: 86 p; Dissertation Abstr. 18(1): 60 (Jan., 1958).
49. Becker, E. S., and E. F. Kurth. 1958. Tappi 41(7): 380–4.
50. Beglinger, E. 1957. Wood and Wood Prods. 62(12): 32, 35.
51. Beglinger, E. 1958. Noeast. Logger 6(7): 26–7, 32–3.
52. Beglinger, E. 1958. U. S. Forest Prod. Lab. Rpt. No. 496 (Revised).
53. Beglinger, E. 1958. Wood and Wood Prods. 63(1): 36, 64, 65.
54. Beglinger, E., and G. Locke. 1957. Econ. Botany 11(2): 160–73 (April-June).
55. Belyaevskii, I. A. 1957. Khim, Nauka i. Prom. 2: 432–6; C. A. 52: 4169.
56. Bick, R. I. C., and P. S. Clezy. 1958. Chem. & Ind. 21: 631–2 (May 24).
57. Bilbruck, J. D. 1958. Dissertation Abstr. 18: 372.
58. Binko, I. 1957. Veda a vyzkum v prûmyslu kožedélnem 2: 13–23.
59. Binko I., I. Kolar, Z. Pospichalova, and I. Iranic. 1957. Veda a vyzkum v prûmyslu kožedélnem 2:77–87.
60. Binns, S. V., B. Halpern, G. K. Hughes, and E. Ritchie. 1957. Australian J. Chem. 10: 480.
61. Bishop, C. T. 1957. Can. J. Chem. 35: 1010.
62. Bjorkman, A., and B. Persson. 1957. Svensk Papperstidn. 60: 285.
63. Black, H. H. 1958. Ind. Eng. Chem. 50(10): 95A.
64. Blanchard. 1958. Chem. & Ind.: 293.
65. Bland, D. E. 1958. Holzforschung 12: 19.
66. Blazej, A., and E. Markusovská. 1958. Veda a vyzkum v prûmyslu kozedélnem 3: 43–52, 119–26.
67. Blears, J. G., and R. D. Haworth. 1958. J. Chem. Soc.: 1985–7.
68. Bock, L. H., and J. K. Anderson. 1958. J. Polymer Sci. 28: 121.
69. Bonewitz, P. W., E. H. Fults, and S. W. Hockett. 1958. U. S. Patent 2,826. 552 (March 11).
70. Borisek, R., and V. Stanik. 1958. Tappi 41: 188A.
71. Boyer, J. P., R. A. Eade, H. Locksley, and J. J. H. Simes. 1958. Australian J. Chem. 11: 236.
72. Bradley, J. J. 1957. U. S. Patent 2,805,168 (Sept. 3).
73. Bredenberg, J. B-Son. 1957. Acta Chem. Scand. 11: 98, 927, 932.
74. Brewerton, H. V. 1958. New Zealand J. Sci. 1: 220.
75. Briggs, L. H., and R. C. Cambie. 1958. Tetrahedron 2: 256–70.
76. Brown, E. C., W. H. Driesen, and J. S. Guepet. 1958. Can. Patent 554,689 (March 18).
77. Brown, G. L., and E. A. Nolan. 1958. Can. Patent 557,750 (May 20).
78. Brown, H. 1958. Noeast. Logger 6 (8): 39.
79. Browning, W. C. 1957. Can. Patent 549,681 (Dec. 3).
80. Browning, W. C. 1957. Ind. Eng. Chem. 49: 1401.
81. Browning, W. C. 1957. U. S. Patent 2,800,449 (July 23).
82. Bruun, H. H. 1957. Paper and Timber 39: 221, 341; Bruun, H. H., and P. Jalava. 1957. Acta Chem. Scand. 11: 401.
83. Buckley, W. D., and P. E. McCoy. 1958. Can. Patent 554,625 (March 18).
84. Button, E. F. 1956. M. S. Thesis. Univ. of Washington (Seattle).
85. Buyevskoi, A. V., and G. A. Petropavlovskii. 1957. Referat. Zhur. Khim. 5: 489.
86. Buzagh, A., and I. Tar. 1957. Magyar Kem Folyoirat 63: 132.
87. Carruthers, W. R., J. E. Hay, and L. J. Haynes. 1957. Chem. & Ind.: 76; Hay, J. E., and L. J. Haynes. 1958. J. Chem. Soc. 2231; Chaudry. 1954. J. Sci. and Ind. Research (India) 16B: 147. Joshi, Tamhane and Dutta. 1957. Current Sci. (India) 26: 147.

88. Carruthers, W. R., R. H. Farmer, and R. A. Laidlaw. 1957–1958. J. Chem. Soc.: 4440, Laidlaw, R. A., and G. A. Smith, Chem. and Ind.: 1325.
89. Chan, W. R., W. G. C. Forsyth, and Ch. H. Hassall. 1957–1958. Chem. & Ind.: 264; Forsyth, Hassall and Roberts. ibid.: 656; J. Chem. Soc.: 3174.
90. Chemical Statistics Handbook. 1957. 4th Ed. Suppl. 2. Manufacturing Chemists Assoc. pp. 39–42 (Dec.).
91. Chopin, J., and G. Grenier. 1958. Chim & Ind. (Paris) 79: 605.
92. Chu, Jeng-Hung, Shan-Hai Hung, and Yu-Hwai Wang. 1956. Hua Hsueh Hsueh Pao 22: 128–32.
93. Chudakov, M. I. 1956. Zhur. Priklad. Khim. 29: 1418.
94. Chudakov, M. I., and S. I. Sukhanovskii. 1956. Trudy Leningrad Lesotekh Akad. 75: 121. 1957. Referat Zhur. Khim. 4: 440.
95. Cisney, M. E., and J. D. Wethern. 1957. U. S. Patent 2,816,832 (Dec. 17).
96. Cisney, M. E., and J. D. Wethern. 1958. Can. Patent 553,323 (Feb. 18).
97. Clark, I. T. 1958. Anal. Chem. 30: 1676.
98. Clark, I. T. 1958. Ind. Eng. Chem. 50: 1125.
99. Clark-Lewis, J. W., and W. Korytnyk. 1958. Chem. & Ind.: 1418.
100. Clark-Lewis, J. W., and M. Mitsuno. 1958. J. Chem. Soc.: 1724.
101. Collins, E. H., and E. M. Williston. 1958. U. S. Patent 2,828,081 (March 25).
102. Correns, E., and K. Edelmann. 1956. Faserforsch. u. Textiltech. 7: 533–40.
103. Cox, J. S., F. E. King, and F. J. King. 1957. Proc. Chem. Soc. (London): 290.
104. Dalton, L. K., and J. A. Lamberton. 1958. Australian J. Chem. 11: 46.
105. Dave, K. G. 1957. Bombay Technol. 7: 127.
106. Davis, J., R. Benning, and M. Baum. 1958. J. Am. Leather Chemists Assoc. 53: 24.
107. Dharmcharee, B. 1957. Vanasarn (Siam) 15(2): 23.
108. Dickey, E. E. 1958. J. Org. Chem. 23(2): 179–84.
109. Djerassi, C., and others. 1958. J. Am. Chem. Soc. 80: 3686.
110. Doev, D. V., and K. S. Kalvdin. 1957. Bulgar. Akad. na Nauk. Inst. za Gorta. Izv. 2: 143.
111. Dorland, R. M., R. A. Leask, and J. A. McKinney. 1958. Pulp Paper Mag. Can. 59(C): 236–46.
112. Doughty, J. B. 1957. U. S. Patent 2,802,815 (Aug. 13).
113. Dryblyanets, E. E. 1957. Khim Nauki i. Prom. 2: 469–74; C. A. 52: 4178.
114. Dryselius, E., B. Lindberg, and O. Theander. 1958. Acta Chem. Scand. 12: 340–2.
115. Duiker, J. A. 1955. Ger. Pat. 927,354 (May 5).
116. Dull, G. G. 1957. Dissertation Abstr. 17: 1453.
117. Efimov, V. A., B. I. Matusyak, and A. I. Gantsevich. 1957. Gidroliz i. Lesokhim Prom. 10 (7): 20–1; C. A. 52: 4981.
118. Ehrensperger, H. 1957. Can. Patent 540,049 (April 23).
119. Ellis, E. L. 1957. Dissertation Abstr. 17: 465.
120. Elofson, R. M. 1957. Can. J. Chem. 25: 926.
121. Endres, H. 1957. Das Leder 8: 222–9.
122. Endres, H. 1958. Chem. Ber. 91(3): 636–8.
123. Endres, H., W. Grassmann, and H. Mathes. 1958. Chem. Ber. 91(1): 141–3.
124. Enzell, C., and H. Erdtman. 1957. Acta Chem. Scand. 11: 902.
125. Erdtman, H., and B. R. Thomas. 1958. Acta Chem. Scand. 12: 267.
126. Erdtman, H., and J. G. Topliss. 1957. Acta Chem. Scand. 11: 1157.
127. Ermolenko, I. N., and M. M. Pavlyuchenko. 1957. Referat. Zhur. Khim. (14): 418; A.B.I.P.C. 29: 195.
128. Evans, W. H., A. McGookin, L. Jurd, A. Robertson, and W. R. N. Williamson. 1957. J. Chem. Soc.: 3510; Whalley. 1958. Chem. & Ind.: 361; Briggs, L. H., and R. C. Cambie. 1958. Tetrahedron 3: 269.
129. Evelyn, S. R. 1958. J. Soc. Leather Trades Chem. 42: 278–88.
130. Fahey, M. D. (Oregon State College) Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 24,635: 116 p.
131. Felicetta, V. F., and J. L. McCarthy. 1957. J. Am. Chem. Soc. 79: 4499.
132. Flaig, W. 1955. Proc. Natl. Acad. Sci. India 24A: 271.
133. Flaig, W. 1956. Cong. intern. sci. sol. 6: 471.
134. Flaig, W., U. Schobinger, and A. Steinmetz. 1957. Landbauforsch. (Völkenrode) 7: 78.
135. Forest Products Laboratory. 1957. U. S. Dept. Agr. Forest Products Lab. Rept. 1577.
136. Freudenberg, K., and F. Niedercorn. 1958. Chem. Ber. 91: 591.
137. Freudenberg, K., and G. Schuhmacher. 1953–1955. Sitzber. Heidelberg. Akad. Wiss. Math. -naturw. Kl. Abhandl.: 127.
138. Freudenberg, K., and L. Knof. 1957. Ber. 90: 2857, 2957.
139. Freudenberg, K., J. M. Harkin, M. Reichert, and T. Fuzukumi. 1958. Chem. Ber. 91: 581.
140. Fuchs, W. 1955. Chem. Ber. 88: 1825.
141. Fukuzumi, T., and T. Shibamoto. 1958. J. Japan Wood Research Soc. 4: 15; C. A. 52: 11413.
142. Funaoka, K., and M. Tanaka. 1957. J. Japan Wood Research Soc. 3: 144, 173; Funaoka, K. ibid. 3: 218.
143. Furman, K. E., and P. C. Watt. 1958. Can. Patent 559,407 (June 24).
144. Ganczarczyk, J. 1957. Przeglad Papierniczy 13: 74, 120.
145. Ganczarczyk, J. 1957. Przeglad Papierniczy 13: 140.
146. Ganguly, A. K., T. R. Seshadri, and P. Subramarian. 1958. Tetrahedron 3: 225.
147. Gardner, J. A. F., and G. M. Barton. 1957. Forest Prods. J. 8: 189, 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 3E of abstracts; Gardner, J. A. F., and H. MacLean. ibid., p. 2E of abstracts, Gardner, J. A. F., G. M. Barton, and H. MacLean. 1957. Can. J. Chem. 35: 1039.
148. Geerards, J. J. T. M., J. F. Kemkes, D. W. van Krevelen, F. Meulenbeld, and H. I. Waterman. 1958. Erdoel. Kohle 11:11–12; C. A. 52: 7672.
149. Gellert, E. 1957. Australian J. Chem. 10: 209.
150. Gelpi, L., and P. Imbert. 1958. Chim. and ind. (Paris) 79: 11.
151. Gierer, J., and B. Alfredsson. 1957. Acta Chem. Scand. 11: 1516.
152. Gierer, J., and B. Alfredsson. 1957. Chem. Ber. 90: 1240.
153. Giesen, J. 1958. U. S. Patent 2,828,297 (March 25).
154. Gmeiner, A. R. 1958. U. S. Patent 2,839,415 (June 17).
155. Goss, W. C. 1958. Can. Patent 554,282 (March 11).
156. Graf, A. E., and Berthodt. 1957–1958. Pharm. Zentralhalle 96: 385; Baxter, J. N., B. Lythgoe, B. Scales, and S. Trippett. Proc. Chem. Soc. (London): 9.
157. Granquist, D. P. The oxidation of hydrogenation lignin from Douglas-fir wood. (Univ. of Washington). Univ. Microfilms (Ann Arbor, Mich.), Publ. No. 22,168. 97 p.; B.I.P.C. 28: 492.
158. Grassmann, W., H. Endres, W. Pauckner, and H. Mathes. 1957. Chem. Ber. 90: 1125–8.
159. Grassmann, W., H. Endres, and W. Pauckner. 1958. Chem. Ber. 91 (1): 134–40.
160. Gray, K. R., and H. L. Crosby. 1957. U. S. Patent 2,801,994 (Aug. 6).
161. Gross, S. K., K. Sarkaner and C. Schuerch. 1958. Anal. Chem. 30: 518.
162. Grothe, C. L. 1958. Noeast. Logger 6(8): 33.
163. Gupta, V. N., and T. R. Seshadri. 1957. J. Sci. Ind. Research (India) 16C(3): 71.
164. Härtel, O., A. v. Wacek, and M. Maralla. 1958. Holzforschung 12: 33.
165. Hägglund, E. K. M., and T. U. E. Enkvist. 1957. Can. Patent 545,863 (Sept. 3).
166. Hägglund, E. K. M., H. M. Rautzenhain, and L. E. G. Hällstrom. 1957. Can. Patent 544, 937 (Aug. 13).
167. Haigh, P. D. 1958. Forest Prods. J. VIII (10): 66A–68A.
168. Haigh, P. D. 1958. Noeast. Logger 6(8): 30–2.
169. Hair, D. 1958. Noeast. Logger 6(7): 20–1, 44–5, 48.
170. Hallet, L. T. 1957. Anal. Chem. 29: 57A.
171. Hampf, F. E. 1958. Noeast. Logger 6(7): 22–3, 37, 49.
172. Hancock, W. V. 1957. Forest Prods. J. 7: 335.
173. Hansen, R. P., and N. J. Cooke. 1957. J. Sci. Food Agr. 8: 482.
174. Hanzawa, M., and T. Sasaya. 1958. J. Japan Wood Research Soc. 4: 125.
175. Harmon, J. P. 1957. U. S. Bur. Mines. Inform. Circ. 7806.
176. Harris, E. E., and D. Hogan 1957. Ind. Eng. Chem. 49: 1393.
177. Harris, J. F., J. F. Saeman, and E. G. Locke. 1958. Forest Prods. J. VIII (9): 248.
178. Hasegawa, M., T. Nakagawa, and S. Yoshida. 1957. J. Japan Forestry Soc. 39: 159.
179. Hasegawa, M., and T. Shirato. 1957. J. Am. Chem. Soc. 79: 450; Hasegawa, M. 1957. ibid. 79: 1738; J. Japan Forestry Soc. 40: 111, Pacheco, H., L. Chronenberger and C. Mentzner. 1957. Soc. de Chim. Biol. B 39: 439; Chopin, J. and H. Pacheco. 1958. IV International Congress of Biochemistry, Vienna, section 1–54, p. 8 of abstracts
180. Hata, K., and M. Sogo. 1958. J. Japan Wood Research Soc. 4(1) 5.
181. Hathway, D. E., and J. W. T. Seakins. 1957. Biochem. J. 67: 239; Hathway, D. E. 1958. J. Chem. Soc.: 520.
182. (a) Haxo, H. E., and G. S. Fills. 1958. Can. Patent 551,576 (Jan. 14).

b) Haxo, H. E., and G. S. Mills. 958. U. S. Patent 2,844,548 (July).

183. earon, W. M. 1958. J. Chem. luc. 35: (10): 498.

184. earon, W. M. 1957. Forest Prods. 7: 432.

185. aron, W. M., H. B. Lackey, and B. Martin. 1958. U. S. Patent 822,358 (Feb. 4).

186. dlund, I., and K. Wilson. 1957. ensk Papperstidn. 60: 582.

187. rgert, H. L., and O. Goldschmid. 58. J. Org. Chem., 23(5): 700.

188. errick, F. W., and L. H. Bock. 58. U. S. Patent 2,819,295 (Jan.

189. ickson, R. 1957. Can. Patent 0,049 (April 23).

190. ignett, T. P., and N. Gilbert. 1957. U. S. Patent 2,801,939 (Aug. 6).

191. Higuchi, T. 1957. Physiol. Plantarum 10: 356.

192. Hirose, Y., and T. Nakatsuka. 1958. J. Japan Wood Research Soc. 4: 26.

193. Hirst, E. L., E. Percival, and R. S. Williams. 1958. J. Chem. Soc.: 1942, Aspinwall, G. O., B. J. Auret, and E. L. Hirst. 1958. ibid.: 221.

194. Hoffman, J. C. 1957. Ph.D. Thesis, McGill University, Montreal, Quebec, 107 p.

195. Hossfeld, R. L., and W. T. Hunter. 1958. Tappi 41(7): 359.

196. Hossfeld, R. L., and F. H. Kaufert. 1957. Forest Prods. J. 7(12): 537.

197. Husemann, E., and E. Spingler. 1957. Makromol. Chem. 24: 79.

198. Husemann, E., and E. Spingler. 1958. Makromol. Chem. 26: 178.

199. Hutchinson, W. H. 1957. Nat. Hist. 66(5): 265.

200. Inagaki, N., and T. Kawakami. 1957. Jap. Patent 2085 (April 3); C. A. 52: 15909.

201. Iseda, S. 1957. Bull. Chem. Soc. Japan 30: 625, 629.

202. Isenberg, I. H., M. A. Buchanan, and L. E. Wise. 1957. Paper Ind. 38: 945, 1042.

203. Ishihara, T., and T. Kondo. 1956. J. Agr. Chem. Soc., Japan 30: 278–81; C. A. 51: 705.

204. Ivanov, H. E. 1957. Assoc. tech. ind. papetière, Bull. No. 6: 249.

205. Ivanov, V. I., A. A. Chuksanova, and L. L. Sergeeva. 1957. Izvest. Akad. Nauk. USSR.: 653; C. A. 51: 14261.

206. Jantzen, L. 1958. U. S. Patent 2,838,483 (June 10).

207. Jayme, G., and H. Semmler. 1957. Das Papier 11: 396.

208. Jenner, R. W. 1958. Noeast. Logger 6(8): 28–9, 48–9, 52.

209. Kahila, S. K. 1957. Paper and Timber 39: 7, 35.

210. Kahila, S. K., and A. Y. E. Rinne. 1957–1958. Paper and Timber 39: 526; Perila, O., and A. Toivonen. 1958. ibid. 40: 159, 207.

211. Kajanne, P., and M. Nieminen. 1957. Paper and Timber 39: 417, 471; Kajanne, P., and Y. Aho. 1958. ibid. 40: 83.

212. Kamaldina, O. O., Y. A. Massov, and S. A. Sapotnitskii. 1956. Trudy Leningrad. Lesotekhn. Akad. 75: 97. 1957. Referat. Zhur. Khim. 7: 510.

213. Kanda, T., and H. Kawakami. 1957. J. Japan Wood Research Soc. 3: 201.

214. Kanda, T., and T. Matsumoto. 1957. J. Japan Wood Research Soc. 3: 147.

215. Kaplan, M. N., and Y. E. Gurevich. 1958. Bumazh. Prom. 33(2): 6; C. A. 52: 11411.

216. Keil, A. R. 1958. Noeast. Logger 6 (): 38.

217. Kenney, H. E., and M. E. Wall. 1957. J. Org. Chem. 22: 468.

218. Kenzie, W. R., P. A. Deutsch, and J. Benkö. 1957. J. Am. Leather Chemists Assoc. 52: 652.

219. Keppler, H. H. 1957. J. Chem. Soc.: 2721.

220. King, F. E., T. J. King, and L. C. Manning. 1957. J. Chem. Soc.: 563.

221. King, F. E., T. J. King, and J. D. White. 1958. J. Chem. Soc.: 2830.

222. King, H. G. C., and T. White. 1957. J. Soc. Leather Trades Chem. 41: 368.

223. (a) King, H. G. C., and T. White. 1957–1958. Proc. Chem. Soc. (London): 341; (b) Horhammer, L., *et al.* 1958. Arch. der Pharm. 291: 269.

224. Kleinert, T. N., and C. S. Joyce. 1957. Pulp Paper Mag. Can. 58: 147.

225. Kleinert, T. N., and C. S. Joyce. 1957. Tappi 40: 813.

226. Kleinert, T. N., and C. S. Joyce. 1958. Tappi 41: 372.

227. Kleinert, T. N., and R. Dlouhy. 1957. Tappi 40: 827.

228. Kobayashi, T. 1957. Jap. Patent 9377 (Nov. 7): C. A. 52: 14170.

229. Kobayashi, T., and Y. Sakai. 1956. Bull. Agr. Chem. Soc. Japan 20: 1–7; C. A. 51: 12485.

230. Kobayashi, T., and Y. Suhara. 1957. Repts. Govt. Chem. Ind. Research Inst. Tokyo 52: 255.

231. Kohlbrenner, P. J., and C. Schuerch. 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 4E of abstracts.

232. Kondo, T., H. Ito, and M. Suda. 1957. J. Japan Wood Research Soc. 3: 151.

233. Kondo, T., H. Ito, and M. Suda. 1956–1958. J. Agr. Chem. Soc. Japan 30: 281, 717; 32: 1.

234. Korolkov, I. I., A. V. Krupnova, E. N. Garmanova, and E. A. Ivlieva. 1958. Gidroliz i. Lesokhim Prom. 11 (2): 1; C. A. 52: 12394.

235. Korolkov, I. I., V. I. Sharkov, and E. N. Garmanova. 1957. Zhur. Priklad. Khim. 30: 586; A.B.I.P.C. 29: 195.

236. Korolkov, I. I., V. I. Sharkov, and V. P. Levanova. 1957. Referat. Zhur. Khim. (14): 418; A.B.I.P.C. 29: 193.

237. Korytnyk, W. 1958. Australian J. Chem. 11: 248.

238. Kozlov, A. I., and P. N. Tretyakov. 1957. Gidroliz. i. Lesokhem. Prom. 10 (7): 20; C. A. 52: 4981.

239. Kranen-Fiedler, U., A. J. Finlayson, and L. D. Hayward. 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 2E of abstracts.

240. Krasnoselov, B. K., and V. N. Kozlov. 1957. Gidroliz i. Lesokhim. Prom. 10 (3): 10; C. A. 51: 13390.

241. Krasnova, A. P., E. A. Parshina, S. I. Sukhanovskii, and M. I. Chudakov. 1957. Zhur. Priklad. Khim. 30: 802.

242. Krasnova, A. P., S. I. Sukhanovskii, and M. I. Chudakov. 1957. Zhur. Priklad. Khim. 30: 1827; C. A. 52: 11409.

243. Kratzl, K. 1956. Mikrochim. Acta.: 159.

244. Kratzl, K., G. Billek, E. Klein, and K. Buchtela. 1957. Monatsh. 88: 721.

245. Kratzl, K., and G. Hofbauer. 1958. Monatsh. Chem. 89: 96.

246. Kratzl, K., and H. Silbernagel. 1956. Mitt. österr. Ges. Holzforsch. 8: 9.

247. Kremlevskii, P. P. 1957. Khim. Nauka i. Prom. 2: 480; C. A. 52: 4172.

248. Kuriyama, A. 1958. J. Japan Wood Research Soc. 4: 30.

249. Kuroki, K. 1957. J. Japan Wood Research Soc. 3: 57, 85; Miyazaki, M., and M. Yasue. 1958. ibid. 4:71.

250. Laumas, K. R., and T. R. Seshadri. 1958. J. Sci. Ind. Research (India) 17B: 167.

251. Lebedev, N. V., and B. O. Lyubin. 1957. Khim. Nauka i. Prom. 2: 437; C. A. 52: 4170.

252. Lewis, H. F. 1958. J. Chem. Educ. 35(10): 482.

253. Lindberg, B. 1956. Svensk Papperstidn. 59: 531.

254. Linderot, J. 1957. Svensk Papperstidn. 59: 37.

255. Lindgren, B. O., and H. Mikawa. 1957. Acta. Chem. Scand. 11: 826.

256. Lipsitz, P. 1957. Can. Patent 543,895 (July 23).

257. Liu, C. T., and J. Y. Loh. 1957. Hua Hsueh Hsueh Pao 23: 259.

258. Lo, T.-B., Y. T. Lin, and T. H. Lin. 1956. J. Chinese Chem. Soc. (Taiwan) 3:30; C. A. 52: 15446.

259. Luner, P., G. A. Dubey, L. A. Boggs, and A. J. Wiley. 1958. Forest Prods. J. 8:82.

260. Lynch, D. L., and C. C. Lynch. 1958. Nature 181: 1478.

261. Lyness, W. I., and C. Schenker. 1957. Tappi 40(10): 791.

262. McKibbins, S. W. 1958. Kinetics of the acid catalyzed conversion of glucose to 5-hydroxy-methyl-2-furaldehyde and levulinic acid. Unpublished Ph.D. thesis. Chemical Engineering Dept., University of Wisconsin.

263. McKnight, T. S., and S. G. Mason. 1958. Svensk Papperstidn. 61: 383.

264. Malm, C. J., K. T. Barkey, E. B. Lefferts, and R. J. Gielow. 1958. Ind. Eng. Chem. 50: 103.

265. Marshall, H. B., and A. C. Shaw. 1957. U. S. Patent 2,794,790 (June 4).

266. Marshall, H. B., and A. C. Shaw. 1958. Can. Patent 557,722 (May 20).

267. Martin, R. A. 1956. Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 13,708 111 p.); B.I.P.C. 27: 1092.

268. Matsuura, S. 1957. Pharm. Bull (Tokyo) 5: 195.

269. Meister, M. B. Zorn, and G. Mauthe. 1957. Can. Patent 550,315 (Dec. 17).

270. Meister, M., B. Zorn, and G. Mauthe. 1957. U. S. Patent 2,798,043 (July 2).

271. Mayer, W. G., and J. G. Coma. 1958. Chem. Eng. Progr. 54(5): 178.

272. Minshall, W. H. 1957. Rubber and resin content of native and introduced plants of Canada. Canada Department of Agriculture.

273. Mirov, N. T., and Iloff. 1958. Amer. Pharm. Assoc. J. Sci. Ed., 47(6): 404.

274. Mitsuno, M., and M. Yoshizaki. 1957. J. Pharm. Soc. Japan 77:557, 1208.

275. Mongolsuk, S., A. Robertson, and R. Towers. 1957. J. Chem. Soc.: 2231.

276. Morgan, B. E., and G. K. Dumbauld. 1957. Can. Patent 555,290 (June 13).

277. Morgan, B. E., and G. K. Dumbauld. 1958. U. S. Patent 2,840,483 (June 24).

278. Mors, W. B., O. R. Gottlieb, and C. Djerassi. 1957. J. Am. Chem. Soc. 79: 4507; Gottlieb, O. R., and W. B. Mors. 1958. ibid.: 2263.

279. Motl, O., V. Herout, and F. Sorm. 1957. Coll. Czech. Chem. Communs. 22: 785.

280. Motl, O., V. Herout, and F. Sorm. 1958. Chem. listy 52: 116.

281. Motl, O., V. Sykora, V. Herout, and F. Sorm. 1958. Chem. Listy 52: 316.

282. Mukherjee, S., and A. N. Shrivastava. 1958. J. Am. Chem. Soc. 80: 2536.

283. Nagata, Y., K. Kitao, and I. Tachi. 1957. J. Japan Wood Research Soc. 3: 139.
284. Nair, N. B. 1956. J. Sci. Ind. Research (India) 15C: 155; C. A. 51: 624.
285. Nakano, J. 1958. J. Japan Wood Research Soc. 4:1; Pearl, I. A. 1957. Forest Prods. J. 7: 88; Pearl, I. A., and D. L. Beyer. 1957. Tappi 40: 45.
286. Nakano, J., K. Hirakawa, A. Ishizu, and N. Migita. 1957. J. Japan Wood Research Soc. 3: 194.
287. Nakano, J., A. Ishizu, and N. Migita. 1958. J. Japan Wood Research Soc. 4: 1.
288. Narayanamurti, D. 1957. Holz Roh-u. Werkstoff 15: 370.
289. Nikitin, N. I., S. D. Antonovskii, and M. A. Mikhailova. 1957. Zhur. Priklad. Khim. 30: 750.
290. Nikitin, V. M. 1957. Referat. Zhur. Khim. 7: 506.
291. Nikitin, V. M., and A. V. Obolenskaya. 1957. Referat. Zhur. Khim. 4: 444.
292. Nokihara, E., M. J. Tuttle, V. F. Felicetta, and J. L. McCarthy. 1957. J. Am. Chem. Soc. 79: 4495.
293. Nozoe, T., K. Takase, and M. Ogata. 1957. Chem. & Ind.: 1070.
294. Odincovs, P., and J. Beinarts. 1957. Latvijas Akad. Vestis (9): 87; C. A. 52: 11411.
295. Odincovs, P., and J. Beinarts. 1958. Latvijas Akad. Vestis: 67; C. A. 52: 15902.
296. Odincovs, P., and J. Beinarts. 1958. Latvijas Akad. Vestis: 71; C. A. 52: 16739.
297. Odinkovs, P. N., V. Kalnina, and C. A. Sobolevskii. 1957. Gidroliz i. Lesokhim. Prom. 10(1): 4; C. A. 51: 11712.
298. Odintsov, P. N., V. K. Kalnina, and C. A. Sobolevskii. 1957. USSR Patent 105,278 (April 25); C. A. 51: 11715.
299. Oshima, M., J. Kusama, and T. Ishii. 1956. Jap. Patent 8670 (Oct. 9); C. A. 52: 15940.
300. Overcash, D. M., and R. B. Parks. 1958. Can. Patent 552,298 (Jan. 28).
301. Pacheco, H. 1957. Bull. Soc. Chim. Biol. 39: 971.
302. Panasyuk, V. G. 1956. Trudy Leningrad Lesotakh Akad. 75: 133; 1957. Referat Zhur. Khim. 4: 440.
303. Panasyuk, V. G. 1957. Zhur. Priklad. Khim. 30: 498, 813, 1049, 1185.
304. Panasyuk, V. G. 1957. Zhur. Priklad. Khim. 30: 598, 813, 1049; C. A. 51: 14261.
305. Panasyuk, V. G., V. V. Dal, and L. V. Panasyuk. 1956. Zhur. Priklad. Khim. 29: 144.
306. Pascoe, T. A., J. S. Buchanan, E. H. Kennedy, and G. Sivola. 1958. Presented at the TAPPI Alkaline Pulping Conf. (Sept. 24–6). Hot Springs, Ark. To be published in Tappi.
307. Pavanaram, S. K., and L. R. Row. 1957. J. Sci. Ind. Research (India) 16B: 409.
308. Pearl, I. A. 1957. Forest Prods. J. 7: 427.
309. Pearl, I. A. 1958. Forest Prods. J. 8: 38.
310. Pearl, I. A. 1958. J. Chem. Educ. 35: 502.
311. Pearl, I. A. 1958. Paper Ind. 40 (1): 30.
312. Pearl, I. A., *et al.* 1957–1958. Tappi 40: 374; ibid. 41: 255, 621; 133rd A.C.S. meeting, San Francisco, Calif. April, 1958, 1958. p. 5E of abstracts.
313. Pearl, I. A., D. L. Beyer, and E. E. Dickey, 1958. J. Org. Chem. 23: 705.
314. Pearl, I. A., D. L. Beyer, and B. Johnson. 1958. Tappi 41: 255.
315. Pearl, I. A., D. L. Beyer, B. Johnson, and S. Wilkinson. 1957. Tappi 40: 374.
316. Pepper, H. 1958. Noeast. Logger 6 (8): 38.
317. Peter, R. 1958. Noeast. Logger 6(7): 28, 46.
318. Plump, R. E., and J. W. Carroll. 1958. U. S. Patent 2,823,184 (Feb. 11).
319. Polcin, J. 1956. Chem zvesti 10: 450.
320. Poplavskii, K. M. 1956. Trudy Plodoovoshch. Inst. im. I. V. Michurina 9: 154.
321. Popov, I. D. 1957. Izvest. Inst. Biol. Bulg. Akad. Nauk. 7: 149; 1957. Referat. Zhur. Khim. 17: 388.
322. Price, F. A. 1958. Pulp Paper Mag. Can. 59(3): 88.
323. Provost, L. R. 1958. Can. Patent 551,577 (Jan. 14).
324. Rahman, M. B., A. A. Khan, and S. M. Iman. 1957. Pakistan J. Forestry 7: 145.
325. Raman, S. P., and A. K. Barua. 1957. J. Indian Chem. Soc. 34: 912.
326. Rao, P. S., and R. K. Sharma. 1957. Indian Acad. Sci. Proc., Sect. A, 45: 24.
327. Reeder, B. J., and R. E. Kremers. 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 9E of abstracts.
328. Reese, E. T. 1957. Congr. Intern. Botan. 8e, Paris, Sect. 21/27: 17; C. A. 52: 7687.
329. Riehm, T. 1957. U. S. Patent 2,778,-751 (Jan. 22).
330. Risi, J. 1958. Noeast. Logger 6(7): 24, 36, 38.
331. Ritter, J. J. 1958. U. S. Patent 2,823,178 (Feb. 11).
332. Roberts, E. McC., and R. V. Lawrence. 131st meeting of the ACS, Miami, 1957, page 21–0 of abstracts.
333. Roberts, J. R., and A. S. Gregory. 1958. U. S. Patent 2,832,265 (April 29).
334. Rogovin, Z. A., and U. L. Pogosov. Gidroliz i. Lesokhim. Prom. 11(1): 4; C. A. 52: 8543.
335. Root, D. F. 1956. Kinetics of the acid catalyzed conversion of xylose to furfural. Unpublished Ph.D. thesis. Chemical Engineering Dept., University of Wisconsin.
336. Roux, D. G. 1957–1958. Nature 179: 305; 181: 1454; Chem. & Ind.: 161; Clark-Lewis, J. W., and T. White. 1958. J. Soc. Leather Trades Chemists J. 41: 368; Pardo, L. L., and E. Ricci. 1957. Rev. Invest. For., B. Aires 1(½): 59.
337. Rudman, R., and E. W. B. Da Costa. 1958. The causes of natural durability in timber. 1. The role of toxic extractives in the resistance of tallowwood to decay. 2. The role of toxic extractives in the resistance of silvertop ash to decay. Commonwealth Scientific and Industrial Research Organization, Australia.
338. Rudman, P., and E. W. B. Da Costa. 1958. Nature 181: 721.
339. Russell, J. K., and G. J. Byrd. 1957. Can. Patent 549,364 (Nov. 26).
340. Sagajllo, I. 1957. Rubber Chem. and Technol. 30: 639.
341. Sakakibara, A., T. Araki, and S. Takahashi. 1957. Bull. Govt. Forestry Expt. Sta. (Japan) (93): 113; C. A. 51: 18589.
342. Sandermann, W., and H. H. Dietrichs. 1957. Umshau Fortschr. Wiss. u. Tech. 57: 197; Holz Roh-u. Werkstoff 15: 281.
343. Sapotnitskii, S. A., O. D. Kamaldina, and Y. A. Massov. 1956. Gidroliz. i Lesokhim. Prom. 7: 14; 1957. Referat. Zhur. Khim. 9: 528.
344. Satwalekar, G., and Rao. 1957. J. Indian Inst. Sci. 39: 195.
345. Savard, J. 1957. Inds. Aliment et Agr. (Paris) 74: 469; C. A. 51: 18591.
346. Schaffner, K., and others. 1958. Proc. Chem. Soc. (London): 353; Helv. Chim. Acta 41: 152.
347. Scheffer, T. C. 1957. J. Forestry 55: 434; MacLean, H., and J. A. F. Gardner. 1958. Forest Prods. J. 8: 107.
348. Schildknecht, H., and G. Rauch. 1958. IVth International Congress of Biochemistry, Vienna. Section 11–45. p. 145 of abstracts.
349. Schobinger, U. 1958. Sc. D. Thesis. Eidgenössische Technische Hochschule, Zurich.
350. Schrecker, A. W. 1957. J. Am. Chem. Soc. 79: 3823; Schrecker, A. W., and J. L. Hartwell. 1957. ibid. 79: 3827.
351. Schubert, W. J., S. N. Acerb and F. F. Nord. 1957. J. Am. Chem. Soc. 79: 251.
352. Schubert, W. J., and F. F. Nord. 1957. Advances in Enzymology 18: 349.
353. Schulze, W. A. 1957. U. S. Patent 2,794,749 (June 4).
354. Schwenzon, K. 1955. Zellstoff u. Papier 4: 140–2.
355. Schwerin, G. 1958. Holzforschung 12: 43.
356. Sengupta, P., S. Choadhury and H. Khastgir. 1958. Chem. & Ind.: 861.
357. Sera, A., and R. Goto. 1957. Wood Research 18: 27.
358. Sergeeva, L. L., A. A. Chukhanova, and N. N. Shorygina. 1957. Izvest. Akad. Nauk. SSSR: 653; C. A. 51: 14261.
359. Sharkov, V. I. 1957. Khim. Nauka i. Prom. 2: 402–7; C. A. 52: 417[illegible].
360. Sharkov, V. I., and O. A. Dobush. 1956. Gidroliz i. Lesokhim. Prom. 9 (8): 3; C. A. 51: 7711.
361. Sharkov, V. I., and O. A. Dobush. 1956. Zhur. Priklad. Khim. 29: 1411; C. A. 51: 1599.
362. Sharkov, V. I., I. I. Korolkov, and E. N. Garmanova. 1957. Referat. Zhur. Khim. (14): 418; A.B.I.P.C. 29: 197.
363. Sharkov, V. I., I. I. Korolkov, and A. V. Krupnova. 1954. Zhur. Priklad. Khim. 27: 319–26; B.I.P.C. 28: 469.
364. Sharples, A. 1957. Trans. Faraday Soc. 53: 1003.
365. Shimazono, H., W. J. Schubert, and F. F. Nord. 1958. J. Am. Chem. Soc. 80: 1992.
366. Simionescu, C., and N. Simionescu. 1958. Celuloza si hîrtie 7: 71.
367. Simmons, F. C. 1958. Noeast. Logger 6(7): 18 (Jan.).
368. Simmons, F. C. 1958. Noeast. Logger 6(8): 33.
369. Skrynnik, I. V., S. I. Sukhanovskii, and M. I. Chudakov. 1958. Zhur. Priklad. Khim. 31: 655.
370. Smith, L. V., and E. Zavarin. 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 10E of abstracts.
371. Snyder, F. H. 1958. U. S. Patent 2,835,611 (May 20).
372. Stanek, D. A. 1958. Tappi 41: 101.
373. Steinberg, J. C., and K. R. Gray. 1958. U. S. Patent 2,823,223 (Feb. 11).
374. Sukakibara, A., T. Araki, and S. Takahashi. 1957. Bull. Govt. Forestry Expt. Sta. 93: 113.
375. Sukhanovskii, S. I., and M. I. Chudakov. 1956. Trudy Leningrad. Lesotekh. Akad. 75: 109; 1957. Referat. Zhur. Khim. 4: 441.

376. Sukhanovskii, S. I., and M. I. Chudakov. 1957. Bumazh Prom. 32(2): 8.
377. Sultze, R. F. 1957. Tappi 40: 985; Mugg, J. B. Ph.D. thesis, Institute of Paper Chemistry, Appleton, Wis.; Janek, D. A. 1958. Tappi 41: 601.
378. Tanaka, J., and T. Kondo. 1958. Japan Wood Research Soc. 4: 34.
379. Thompson, W. E. 1958. U. S. Patent 828,258 (March 25).
380. Toppel, O. 1958. Can. Patent 559,194 (June 24).
381. Tomlinson, G. H., G. H. Tomlinson J. R. G. Bryce, and N. G. M. Rick, 1958. Pulp Paper Mag. Can. 59(C): 247.
382. Torto, F. G. 1957. Nature 180 (4591): 864.
383. Traynard, P., and F. Barnoud. 1957. Assoc. tech. ind. papetière, Bull. (6): 257.
384. Tschesche, R., and K. Wiensz. 1958. Chem. Ber. 91: 1504.
385. Van Blaricom, L. E., and K. R. Gray. 1957. Can. Patent 537,334, 537,335 (Oct. 8).
386. Van Blaricom, L. E., K. R. Gray, and F. G. Ward. 1958. Can Patent 554,293 (March 11).
387. Wacek, A. U., W. Limontschew, C. Aas. 1957. Ind. Eng. Chem. 49: 1389.
388. Walker, H. M. 1957. U. S. Patent 2,816,100 (Dec. 10).
389. Walls, F., O. Collera, and A. Sandoval L. 1958. Tetrahedron 2: 173.
390. Wawrzyniak, H. 1957. Przeglad Papierniczy 13: 249, 281.
391. White, T., and H. G. C. King. 1958. Chem. & Ind.: 291.
392. Winter, A. O. 1957. Suomen Kemistilehti 30A: 141; C. A. 52: 2433.
393. Woodruff, S. A. 1957. Battelle Tech. Rev. 6(9): 3.
394. Yasue, M. 1958. J. Japan Wood Research Soc. 4: 22.
395. Yasue, M., and Y. Kato. 1957. J. Pharm. Soc. Japan 77: 1045.
396. Yates, P., and G. Stout. 1958. J. Am. Chem. Soc. 80: 1691.
397. Yokota, T., and M. Yasue. 1957. Bull. Govt. For Exp. Sta. 103: 83.
398. Zakoschchikov, A. P., and O. T. Chernova. 1957. Gidroliz i. Lesokhim. Prom. 10(6): 5; C. A. 52: 3329.
399. Zavarin, E., and A. B. Anderson. 1957. J. Org. Chem. 22: 1122; Zavarin, E. 1958. ibid. 23. 1198, 1264; 133rd A.C.S. meeting, San Francisco, Calif. April, 1958. p. 3E of abstracts, Anderson, A. B., E. Zavarin, and T. C. Scheffer. 1958. Nature 181: 1275.
400. Zeiss, H. H., and F. W. Grant. 1957. J. Am. Chem. Soc. 79: 1201.
401. Zhitkov, A. V. 1958. Bumazh. Prom. 33(2): 4.

IMPORTANT ACTIVITIES IN

Quality Control in 1958

A. C. Barefoot
Chairman, FPRS Quality Control Division

A DECIDED NEED FOR RE-FOCUSING attention upon decision-making techniques of a mathematical nature is the basis for this annual review of 1958. For illustrating the present status of quality control in the wood industries, only selected activities are mentioned; in no way is this an all-inclusive report.

Much of the fervor of earlier applications of statistics to wood manufacturing problems has been replaced with an appreciation of the value and limitations of this management tool. Future growth will very likely be at a compounding rate as more and better techniques become widely known and used. In 1958 the quality control men generally were not expected to perform miracles and provide the answers to all problems, but they were looked upon as one group of logical thinkers and systematic workers searching out the patterns of action necessary for the proper functioning of an organization.

The Author: A. C. Barefoot holds BS and MS degrees in wood technology from North Carolina State College, and a DF degree from Duke University. He is now an assistant professor, at the N. C. State College School of Forestry.

Among the reported uses of statistics in wood utilization, the work of Dr. L. J. Lussier of North Paper Company, Quebec, Canada, has exciting possibilities for re-opening research in timber harvesting methods. His use of advanced statistical methods in studying harvesting costs of pulpwood and in controlling these costs at expected levels is a brave and fresh step into the area long left fallow. He presented a paper at the FPRS National Meeting in Madison.

Another activity of equal brilliance is the adoption of linear programming for making decisions concerning day-to-day operations and procurements of wood manufacturing concerns. At the Carolinas–Chesapeake Section meeting, James S. Bethel, Norman D. Jackson, and George W. Smith reported the use of these sophisticated methods in making sawmilling decisions. In June 1959 they will present a paper on this subject at the FPRS San Francisco National Meeting. The Wood Products Laboratory of North Carolina State College is extending the use of these high speed computer techniques to other problems in the wood field.

Professor Aubrey E. Wylie, continuing his efforts in statistical quality control, gave a talk on "Quality Control in Furniture Manufacture" at the Battle Creek–Kalamazoo Section of the American Society of Quality Control. The presentation of this paper and the work he is doing in the control of particle board quality indicate that statistics is being used in the furniture industry; at least in some units of the industry. Companies such as the Singer Manufacturing Company, Nickey Brothers, and Brunswick–Balke–Collender substantiate this evidence by their continued and expanded use of statistical quality control in their operations. The fact that these individual companies can be cited for their long, continued use of S.Q.S. certainly places a real value upon the effectiveness of a well-grounded program of statistical control.

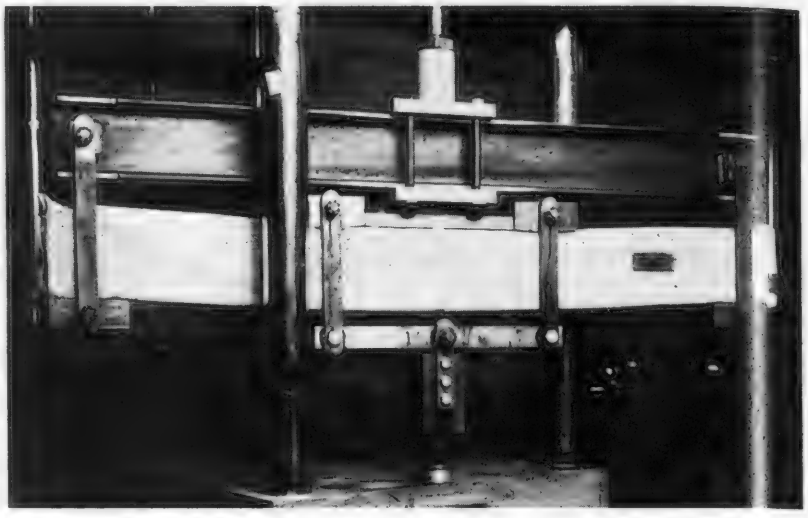
The foregoing citations provide the basis for thinking that mathematical desicion-making techniques are solidly grounded in the wood industry and are now gaining a more sober if un-spectacular acceptance. The events of 1958 indicate the widespread and deep roots that exist and that are now being somewhat taken for granted in this business of statistical quality control.

EFFECT OF REPEATED LOADING AND SALT-WATER IMMERSION ON

Flexural Properties of Laminated White Oak[1]

A. D. FREAS and FRED WERREN
Assistant to the Director, and Engineer, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Laminated beams, tested dry and after immersion in salt water, showed no loss in bending strength or stiffness after 9 million cycles at 50% of ultimate strength. The glue bonds also showed no strength loss.



Wet-test laminated beam being subjected to repeated loading while enclosed in a water-tight container.

MANY OF THE STRUCTURAL MEMBERS of modern wood naval vessels are of glued laminated construction. Considerable data are available on the static properties of laminated members, on the fatigue properties of glued joints, and on the effects of outdoor exposure on glue joints exposed without stress. In service, however, the laminated members are subjected to repeated loadings while exposed to water or to high humidity.

In view of the lack of information about the combined effects of water exposure and repeated loading, the Bureau of Ships initiated a project at the U. S. Forest Products Laboratory to investigate the problem. This report presents the results of that study which was completed in January, 1957.

[1] This research was conducted in cooperation with the Bureau of Ships, Department of the Navy, under Order No. BuShips/1700S-566, Index No. NS-032-001.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Authors: Alan Freas holds BS and MS degrees in civil engineering from the University of Wisconsin. He was originally from the FPL, and returned after two years in Washington as Assistant Director, Division of Forest Products Research, Forest Service.

Fred Werren holds a BS in civil engineering from the University of Wisconsin, and has spent the major part of his time at the FPL on research in laminated wood and plastics.

Scope of Study

Laminated beams of white oak were divided into five groups, each of which was exposed and tested as follows:

Group 1—dry control.—The specimens were tested in bending without exposure to water or to repeated load. The results from these tests were used as a basis of comparison for the test results from groups 2, 3, and 4.

Group 2—repeated load, wet exposure.—After being immersed unstressed in salt water for 3 months, the specimens were encased in containers partially filled with salt water; they then were loaded repeatedly as beams for approximately 3, 6, or 9 million cycles at a stress equal to 50 per cent of the ultimate strength of the corresponding wet control (group 4). After completion of the specified number of cycles, the specimens were tested to failure in bending while still wet.

Group 3—repeated load, dry exposure.—The specimens were subjected to repeated loadings in an atmosphere maintained at 75° F. and 65 per cent relative humidity. Loads were applied for approximately 3, 6, or 9 million cycles at a stress equal to 50 per cent of the ultimate strength of the corresponding dry control (group 1). After completion of the specified number of cycles, the specimens were tested to failure in bending.

Group 4—wet control.—After being immersed unstressed in salt water for approximately 3 months, the specimens were tested to failure in bending while wet. The exact period of exposure was three months plus the period during which the corresponding wet fatigue specimen (group 2) was undergoing repeated loading.

Group 5—cyclic exposure and repeated load.—One-half the specimens of this group were tested while dry as controls, without any previous exposure to water or repeated load. The remainder of the specimens were exposed to three cycles, each consisting of immersion for three months in salt water and drying for one month at 75° F. and 65 per cent relative humidity. After completion of the three cycles of exposure, the specimens were subjected to repeated loading for approximately 3, 6, or 9 million cycles at a stress equal to 50 per cent of the strength of corresponding dry controls. There were then tested to failure in bending while dry.

General

The stress level for the repeated loadings on group 2 specimens was intended to be at 50 per cent of the ultimate strength of the corresponding dry controls. The moisture increase, resulting from immersion, so reduced strength that failure occurred during repeated loading of the two specimens tested at this stress level. Succeeding specimens were tested at 50 per cent of the wet strength as described earlier.

Specimens from group 5 were tested in repeated loading at 50 per cent of the dry control strength. This, however, resulted in an applied repeated-load of about 58 per cent of the strength of the individual repeated-load specimen, as is discussed later in this report.

Test Specimens

The white oak boards selected were of average specific gravity, free of grain slope steeper than 1 in 15, and free of knots in the critical central length of the final test specimens. In some instances, small knots and local areas of grain deviation could not be completely eliminated because of a limited supply of material. Boards containing such defects were cut so as to place the defects in noncritical areas of the finished test specimens.

The boards were cut into lengths of approximately 45 inches, and were assembled into groups of six laminations. The outer laminations (at least 1 and generally 2 on each side) were of the highest possible quality.

Nine beams approximately 3¾ inches deep, 8 inches wide, and 45 inches long, and 9 others approximately 3¾ by 4 by 45 inches were fabricated. The laminations were surfaced to ⅝ inch in thickness and were double spread on a mechanical spreader with a phenolresorcinol adhesive at a rate of at least 60 pounds per 1,000 square feet of joint area.

Immediately after the glue was spread, the boards were laid up and pressure was applied after 45 minutes of closed assembly time. The initial pressure was 150 pounds per square inch, clamp spacing was 5 inches, and 2-inch-thick wood cauls were used. The assemblies were cured for at least 6 hours at a glue-line temperature of 150° F. and a relative humidity that would give an equilibrium moisture content of about 12 per cent. After completion of the curing period, the beams were conditioned at 80° F. and 65 per cent relative humidity.

The 8-inch-wide assemblies were each cut into four test specimens, 1¾ inches wide, 3¾ inches deep, and 43 inches long. One specimen from each assembly was assigned to each of groups 1 through 4. Thus, the four specimens in the various groups were side matched.

The 4-inch-wide assemblies were each cut into two test specimens, 1¾ inches wide, 3¾ inches deep, and 43 inches long, for group 5 tests. One was assigned as a control and the other for cyclic exposure and repeated loads. Each pair of specimens was side matched.

Test Methods

The specimens of groups 1 and 3 were conditioned to constant weight at 75° F. and 65 per cent relative humidity prior to test. The specimens of group 3 were loaded in fatigue in a room maintained at these conditions.

The specimens of groups 2 and 4 were immersed for approximately 3 months in salt water[3] at room temperature. The period of immersion for the specimens of group 2 was 90 days. The specimens of group 4 were immersed for 90 days plus the period

Table 1.—RESULTS OF BENDING TESTS OF LAMINATED WHITE OAK AFTER REPEATED LOADING AND AFTER IMMERSION IN SALT WATER

Specimen No.	Cycles of repeated loading No.	Average moisture content Per cent	Modulus of elasticity: Test value 1,000 psi	Modulus of elasticity: Ratio to Dry control	Modulus of elasticity: Ratio to Wet control	Modulus of rupture: Test value Psi	Modulus of rupture: Ratio to Dry control	Modulus of rupture: Ratio to Wet control
Group 1—Dry Control								
A-1		11.4	1,202			9,340		
B-1		11.4	1,279			9,980		
C-1		11.6	1,282			7,580		
D-1		11.5	1,139			9,540		
E-1		11.5	1,297			11,180		
F-1		11.9	1,207			13,100		
G-1		11.7	1,572			13,240		
H-1		11.8	1,097			12,470		
I-1		12.0	1,325			10,570		
Group 3—Subjected to Repeated Loadings, Tested While Dry								
A-3	3,000,000	11.4	1,296	1.079		9,210	0.986	
B-3	3,006,000	11.1	1,300	1.016		9,650	.956	
C-3	3,001,300	11.4	1,323	1.031		7,410	.978	
Av.	3,002,400			1.042			.973	
D-3	6,107,900	11.6	1,319	1.158		10,150	1.065	
E-3	6,000,000	11.2	1,616	1.246		12,350	1.105	
F-3	6,090,000	11.1	1,409	1.166		14,140	1.079	
Av.	6,066,000			1.190			1.083	
G-3	9,271,900	11.1	1,616	1.028		10,450	.790	
H-3	9,075,100	11.0	1,405	1.280		14,830	1.189	
I-3	9,429,000	11.6	1,324	1.000		8,780	.830	
Av.	9,258,700			1.103			.936	
Group 4—Wet Control								
A-4		41.8	839	0.698		5,410	0.589	
B-4		43.7	842	.658		6,010	.602	
C-4		40.6	984	.775		5,620	.742	
Av.				.710			.644	
D-4		42.4	936	.822		5,480	.574	
E-4		43.2	942	.726		5,780	.517	
F-4		36.1	995	.824		7,890	.602	
Av.				.791			.564	
G-4		39.1	1,135	.722		6,920	.523	
H-4		42.8	858	.782		7,160	.574	
I-4		42.3	910	.687		6,660	.630	
Av.				.730			.576	
Group 2—Soaked, Subjected to Repeated Loadings, Tested While Wet								
A-2	20,100	42.9	[1]			[1]		
B-2	261,500		[2]			[2]		
C-2	3,191,000	36.7	914	.712	0.928	5,875	.775	1.045
Av.	[3]3,191,000			[3].712	[3].928		[3].775	[3]1.045
D-2	6,153,000	32.1	832	.730	.889	6,500	.682	1.186
E-2	6,000,100	32.5	1,130	.871	1.200	7,600	.680	1.315
F-2	33,200		[2]			[2]		
Av.	[4]6,076,600			[4].800	[4]1.044		[4].681	[4]1.250
G-2	9,440,000	26.3	1,067	.679	.940	9,220	.698	1.332
H-2	10,169,700	19.4	1,006	.918	1.173	9,240	.741	1.290
I-2	9,273,500	21.4	1,044	.787	1.146	7,590	.718	1.140
Av.	9,627,700			.795	1.086		.719	1.254
Group 5—Dry Control								
J-1		11.2	1,137			11,050		
K-1		10.9	1,525			11,630		
L-1		10.6	990			9,060		
M-1		11.3	1,078			9,440		
N-1		11.1	1,227			8,320		
O-1		10.9	1,386			11,960		
P-1		10.6	1,422			12,290		
R-1		11.3	1,130			7,820		
S-1		10.4	983			10,510		
Group 5—Subjected to Cyclic Exposure and Repeated Loading, Tested Dry								
J-2	3,026,100	14.3	1,323	1.164		9,620	0.871	
K-2	3,026,100	14.0	1,432	.939		10,020	.862	
L-2	3,000,100	14.4	958	.969		7,070	.780	
Av.	3,017,400			1.023			.838	
M-2	140,200		[2]			[2]		
N-2	6,000,600	14.7	1,126	.918		7,170	.862	
O-2	180,600		[2]			[2]		
Av.	[4]6,000,600			[4].918			[4].862	
P-2	355,800		[2]			[2]		
R-2	6,226,800		[2]			[2]		
S-2	261,300		[2]			[2]		

[1] Failed during adjustment of fatigue machine after 20,100 cycles.
[2] Failed in fatigue.
[3] Single value.
[4] Average of two values.

[3] American Society for Testing Materials, Standard Specifications for Substitute Ocean Water, ASTM Des.: D1141–52. Substitute ocean water as described in paragraph 5 of the Standard (without heavy metals) was used.

during which the corresponding specimens of group 2 were undergoing wet exposure in the fatigue machine.

The control specimens of group 5 were conditioned to constant weight at 75° F. and 65 per cent relative humidity prior to test. The other specimens of this group were subjected to the cyclic exposures as described earlier, after which they were reconditioned to approximately constant weight at 75° F. and 65 per cent relative humidity.

The control specimens were tested in bending under 2-point loading on a span of 39 inches, with the load points 13 inches from the supports. The rate of head movement was 0.11 inch per minute.

Specimens of groups 2, 3, and 5 were subjected to repeated loadings in flexure for approximately 3, 6, or 9 million cycles in a fatigue machine. The maximum load was such as to produce a stress in the extreme fiber equal to one-half the ultimate stress of the corresponding control specimen. The minimum load was one-tenth the maximum load. The machine was operated at 500 cycles per minute, and the desired alternating load was kept reasonably constant throughout the test by periodic checks and adjustments. A decrease in load of approximately 100 pounds shut off the machine. After such a shut-off, the machine was adjusted to the desired load.

During repeated loading, the specimens of group 2 were encased in a watertight container partially filled with salt water to maintain the specimens in a wet condition. Repeated loading tended to crack the container. In such instances, the cracks were patched to retain water tightness, but the efficiency of the patching is questionable because specimens apparently dried out somewhat.

After the specified number of cycles of repeated loading were completed, specimens of groups 2, 3, and 5 were tested to failure in bending as described for the control specimens.

Failures

All specimens failed in bending in the wood itself. There was no evidence that any failures originated because of a weakness in the glue bond.

Presentation and Discussion of Data

The results of individual tests are shown in Table 1, together with the ratios of the results to those for the corresponding control specimens. A summary of the ratios is given in Table 2.

Immersion alone (group 4 specimens) resulted in substantial reductions in strength and stiffness. The reductions caused by the increased moisture content are in the range to be expected from the results of tests of a large number of small, clear specimens.[4]

Table 2.—SUMMARY OF RATIOS OF TEST VALUES OF BENDING PROPERTIES TO CONTROL VALUES AFTER VARIOUS TEST CONDITIONS

Group No.	Test condition	Millions of cycles of repeated loading	Ratio to dry control: Modulus of elasticity	Ratio to dry control: Modulus of rupture	Ratio to wet control: Modulus of elasticity	Ratio to wet control: Modulus of rupture
4	Wet control	---	0.71	0.64	----	
		---	.79	.56	----	
		---	.73	.58	----	
3	Subjected to repeated loadings, tested while dry	3	1.04	.97	----	
		6	1.19	1.08	----	
		9	1.10	.94	----	
2	Soaked, subjected to repeated loadings, tested while wet	3	.71	.78	0.93	1.04
		6	.80	.68	1.04	1.25
		9	.80	.72	1.09	1.25
5	Cyclic exposure, subjected to repeated loading, tested while dry	3	1.02	.84	----	
		6	.92	.86	----	

The results of tests on specimens of group 3 indicate that bending strength was not affected by the repeated loading. There is some indication that strength values may decrease after 9 million cycles, but the data are too limited to draw a definite conclusion. The data indicate, however, that stiffness is increased somewhat. While there seems to be no reason to expect an increase in stiffness as a result of repeated loading, the trend is consistent, with individual ratios ranging from 1.000 to 1.280. Since six of the individual ratios are below 1.10, and the average ratio is greatly influenced by the two very high values, it is doubtful that the indicated increase of about 10 per cent is significant.

The ratios of wet strength of group 2 specimens to the strength of the group 4 controls imply that repeated loading of previously soaked specimens substantially increased bending strength. As indicated earlier, the containers in which the specimens were encased during repeated loading cracked and required patching. It is evident from the moisture-content values, particularly those for the 9-million-cycle specimens of group 2, that the patching was not efficient and that considerable drying occurred. Specimen C-2 appears to have dried the least and therefore is probably most indicative of the true effect of repeated loading on soaked specimens. The unknown extent and effect of the partial drying makes interpretation of the data difficult; nevertheless, the data from specimen C-2 and the generally higher ratios to dry controls found for group 2 specimens, as compared with group 4 specimens, indicate that a combination of repeated loading and water immersion causes no greater change in properties than does immersion alone.

Five of the nine specimens of group 5 failed to sustain the desired number of repeated loadings (Table 1), although one intended for 9 million repetitions sustained more than 6 million before it failed. The reason for this is not apparent, although it could result from any one or a combination of four possibilities: (1) poor matching between control and repeated-load specimens; (2) abnormalities in the fiber structure of the repeated-load specimens; (3) a serious weakening effect caused by the cyclic exposure; or (4) differences in moisture content as compared with the control specimens.

Since all repeated-load specimens of group 5 were side matched to an individual control, the specimens were reasonably well matched. Visual examination of the fiber structure of the specimens indicated no abnormality of structure in either repeated-load or control specimens. A weakening effect on the specimens due to the cyclic exposure may be a possible factor. Such a weakening effect, had it occurred, would have been associated with weakening of the wood itself and not the glue bond, since there was no evidence of any primary failure in the glue bonds.

The fourth factor, differences in moisture content, can account for substantial differences in strength and appears to be the most likely reason why failures occurred earlier than expected. The repeated-load specimens had been reconditioned for a month in an atmosphere at 75° F. and 65 per cent relative humidity and appeared to have attained approximately constant weight; however, subsequent moisture determinations showed that the moisture content of the specimens was about 3-½ per cent higher than that of the corresponding controls. Based on average effects of differences in moisture content, as given on page 85 of the Wood Handbook[4], a deficiency on the order of 14 per cent in modulus

[4] U. S. Forest Products Laboratory, Wood Handbook, U. S. Department of Agriculture Handbook No. 72, table 12, 1955.

of rupture would be expected from the higher moisture content alone. This is confirmed from the strength tests of the four repeated-load specimens that did not fail in fatigue, specimens J–2, K–2, L–2, and N–2. On the average, the modulus of rupture of these four specimens was 85 per cent of their control values.

Experience in fatigue testing green wood beams has shown that specimens will withstand 30 million repetitions of stress if the maximum repeated stresses are below the proportional limit. On a species average, the proportional limit of white oak is about 55 per cent of the modulus of rupture. Hence, when fatigue loads are applied at the 50 per cent level, failure is not to be expected at 3, 6, or 9 million cycles. The fatigue loads applied to the cycled specimens were 50 per cent of the load sustained by controls. Since the estimated strength of the cycled specimens was 86 per cent of the strength of their controls, the fatigue loads applied to the cycled specimens were actually about 58 per cent of their static strength. At the 58 per cent stress level, specimens may be expected to fail under repeated loading at considerably less than 30 million cycles. It appears, therefore, that many of the specimens of group 5 failed in fatigue because the level of applied load was about 58 per cent instead of 50 per cent of the static strength of the specimen.

The foregoing discussion indicates that the reason for the fatigue failure of some of the beams in group 5 was due primarily to a mismatching in strength properties because of differences in moisture content.

Conclusions

A limited number of bending tests were made on laminated white oak beams after various conditions of exposure to moisture and repeated loading. Although there was some mismatching of material because of moisture differences between test specimens and controls, two general observations are indicated:

(1) Repeated bending loads up to 50 per cent of the ultimate strength may be applied to a member, while either wet or dry, as many as 9 million times without appreciably changing the bending strength and stiffness.

(2) The glue bond between laminations does not appear to be affected by the combined moisture and loading effects, since none of the primary failures seemed to be influenced by the glue bond.

Flāpreg Flakeboard . . .

RESIN-IMPREGNATED, COMPRESSED WOOD FLAKES

J. W. Talbott
Wood Technologist, Division of Industrial Research, Washington State Institute of Technology, Pullman

This new member of the compreg–impreg family can be manufactured at considerably reduced cost, which should mean wider application. It is hard, strong, dense; has good electrical properties and resistance to moisture and chemical attack.

This four-inch mat of impregnated flakes will be consolidated to a ½-inch Flapreg board of 1.4 specific gravity.

Perhaps the most important consideration leading to the development of those wood products termed compreg and impreg was the matter of improved dimensional stability. Research had shown that an effective method of limiting the shrinking and swelling associated with moisture changes in wood is the formation of an insoluble, thermosetting resin within the cell wall structure of the wood.[2] This can be done by allowing a water solution of a low-molecular-weight phenol-formaldehyde resin to diffuse into the wood, and then, after evaporating the water at moderate temperature, curing the material at a high enough temperature to polymerize the resin. The wood treated in this way has greatly increased dimen-

[1] Presented at Session X, Wood Composition Board (2), FPRS 12th National Meeting, June 22–27, 1958, in Madison, Wis.

[2] Seborg, R. M., and A. J. Stamm. 1956. Effect of resin treatment and compression upon the properties of wood. U. S. Forest Prod. Lab. Report 1383.

The Author: John Talbott was employed in various phases of building construction, including several years as a residential and commercial building contractor, before joining the staff at Pullman.

sional stability and considerable reduction in hygroscopicity.[2]

The practical application of this method has involved the impregnation of veneer by diffusion, necessarily a slow process even under pressure. These veneers are then carefully dried. If the impregnated and dried veneers are first cured and then glued up and pressed in the manner of plywood, the product is known as "impreg." It is of moderate density, good dimensional stability, and has high tensile and flexural strength.

If, on the other hand, the impregnated and dried veneers are glued up in the uncured condition and pressed at high pressure and temperature, the resulting product is known as "compreg." It has a high density (about 1.4), very low water absorption, and high strength, particularly compressive strength.

The commercial use of these admirable materials has been severly limited by the high costs inherent in the method: high-grade wood veneers are required, and labor costs are high due to the necessity of repeated handling of the individual veneers. Some of the uses that have been able to absorb these high costs are propeller blades, metal-forming punches and dies, patterns, cutlery handles, and various novelties. Of these, cutlery handles seem to be the predominant item at the present time.[3]

The aim of the research reported herein has been to develop materials comparable to impreg and compreg, but at low enough cost to realize the large use potentials inherent in their unique combination of physical properties. The approach has been through the use of thin wood flakes as a raw material in an attempt to reduce costs of both raw materials and processing. The first product to emerge from this research essentially duplicated the properties of compreg and has been named "flāpreg" to connote the similarity with this class of product. (The term "flāpreg" is a contraction of *flak*es and im*preg*nation).

Description of the Process

The flāpreg process as presently developed, for producing fully impregnated and compressed board, consists of the following six steps:

1. Preparation of the flakes
2. Initial drying of the flakes
3. Impregnation by spray application of resin solution
4. Re-drying of the impregnated flakes
5. Machine felting
6. Pressing and curing

[3] Gurvitch, J. E. 1957. The past developments and future prospects for compreg. Forest Prod. J. VII (9): 16-A.

Each of these steps is covered more fully below with discussions of some of the considerations involved.

1. Preparation of the Flakes: Thin wood flakes seem to be the logical material form for several reasons:

a. They can be made inexpensively from any solid wood residue.
b. They are adapted to completely mechanized handling throughout the process.
c. They can be made and handled in thinner sections than veneers. Thicknesses in the order of 4 or 5 tracheid diameters afford a high surface-weight ratio and require the resin to penetrate to a depth of only 2 or 3 tracheids.
d. Flakes can be made with minimum damage to the wood structure, which means little loss of strength. Flakes also afford clean-cut, open surfaces for easy absorption of resin.
e. Flakes can be easily made in any range of length-width ratios, thus affording a means of controlling the directional orientation of the wood grain during the felting process. This makes it possible to approximate the properties of either cross- or parallel-laminated compreg.

The flakes used in this experimental work were cut on a 30-inch laboratory disk flaker from green lumber. Either porous or non-porous wood species can be used satisfactorily. Douglas-fir was used for most of the work here since it is considered to be one of the more difficult woods to impregnate. Aspen, cottonwood, sycamore, western red cedar, redwood, ponderosa pine, lodgepole pine, and southern yellow pine were also tried and found to present no problems.

The wood at the time of flaking should be green or at least remoistened to near fiber saturation to minimize curl and breakage of the flakes.

2. Drying of the Flakes: Since the impregnating resin is carried in water solution, it is desirable to dry the flakes to a low moisture content before they are impregnated. This gives more rapid penetration and less tackiness in the impregnated flakes. Moisture contents in the range from 0 to 5 per cent were found to be satisfactory.

3. Impregnation: The resin used was a water-soluble phenol-formaldehyde resin in a low state of polymerization, and was a type formulated for use in commercial compreg.

The use of thin flake material required a radical change from commercial compreg practice in the method of resin application. The high surface-to-weight ratio of the flakes is desirable in that it affords quick resin penetration. This also means, however, that any tackiness of the resin on the surface of the flakes would cause them to clump together in coherent masses, which would greatly complicate mechanical handling of the material in subsequent steps. This clumping would be particularly undesirable in the felting process, which depends on the free fall of individual flakes to form a uniform mat.

This situation rules out the possibility of impregnation by immersion of the flakes in resin solution, as is done with veneers in the compreg process.

It was found, however, that if the resin solution were sprayed onto the flakes in a rotary drum mixer over a period of time (10–15 min.) such that the absorption into the wood practically keeps pace with the rate of application, no troublesome degree of tackiness developed. The low inherent tackiness of the low-molecular-weight resins formulated for impregnation purposes also helps in this respect. The small amount of tackiness that develops in spraying is reduced by the subsequent drying to a level that does not interfere with the critical felting operation.

An important point in the impregnation step is that the amount of resin required is a little greater than in the case of commercial compreg. The reason for this excess of resin is traceable to the mechanical difficulty of felting flakes into a mat of perfectly uniform density. Some lack of uniformity of density between adjacent small areas is of little consequence in a normal flakeboard of light or medium density, but in a highly compressed board such variations are more serious. The goal in flāpreg manufacture is a product as nearly free of air voids as possible (including intra-cellular voids). In pressing such flāpreg boards, as the density increases to its limiting value of about 1.4, the intracellular air voids are eliminated and the compressibility of the board drops to near zero. At this stage, a local area of only slightly lower density will still contain numerous air voids that cannot be eliminated even by large increases in over-all pressure on the board.

It was found that this problem could be overcome by adding resin somewhat in excess of the amount (about 30 per cent) apparently required to saturate the cell wall structure of the wood. In the early part of the press cycle, this excess of resin is free to flow in the molten state, under the influence of the high lateral pressure gradients caused by the density variations. The excess resin is

Flapreg board being trimmed on a conventional table saw equipped with a carbide-tipped blade.

Burning cigarette on glossy surface of the unfinished material as pressed leaves only a brown stain of condensed tars, which is easily wiped off with alcohol.

thus effectively squeezed from the high-density areas into the low-density areas where it fills all the voids and results in a very uniform final density.

The total amount of resin required to insure this equalizing action is about 35 per cent resin solids on the basis of dry wood.

4. **Re-drying:** After impregation, the flakes are dried at a temperature below the curing range of the resin. The optimum moisture content has not been definitely established. Very low moisture contents require higher consolidation pressures, but high moisture contents lower the strength properties of the board. A good compromise seems to be about 5 per cent total volatiles on the basis of dry wood plus resin solids.

5. **Machine Felting:** The re-dried material is next formed into a uniform mat prior to being pressed. In the laboratory, the felting was done by hand in a deckle box. On a commercial scale, the felting would present no new problems with any successful flakeboard felter. Mat thickness was about 8 inches per inch of finished board, which could be reduced by moderate pre-pressing to 4 to 5 inches.

6. **Pressing and Curing:** The consolidation pressure required in pressing ranges from about 700 psi to 2000 psi, depending on the wood density, moisture content at pressing, and the amount of "excess" resin used. Gradual increase of pressure over a period of 2 or 3 minutes appears to aid in elimination of air voids.

Time and temperature for curing, of course, depend on the characteristics of the particular resin used. Phenolic resins designed for impregnation are comparatively slow-curing; they require 15 to 25 minutes at 300° F. for complete cure.

A cooling period in the press before the pressure was released was used to prevent blistering. Reducing the temperature at the center of the board thickness below 200° F. proved to be adequate for small experimental boards. At low moisture contents, it might be possible to eliminate the cooling cycle if a high surface finish is not required.

Due to the high pressures and considerable resin flow, it is necessary to use an effective release material[4] on the caul-plates to prevent sticking.

Properties of Flapreg

Table 1 presents a summary of the average physical properties of typical Douglas-fir flāpreg produced under the following process conditions:

Average flake size:
Thickness, 0.008"
Width ¼"
Length ½"

Resin content (dry wood basis):
35% solids[5]

Moisture content at pressing: (dry wood basis)
7%

Pressing conditions:
Temperature, 325° F
Pressure, 2500 psi
Curing time, 25 min.
Cooling time, 5 min.

Final board dimensions:
½" x 3" x 10"

[4] Dow Corning's No. 7 silicone release agent has been used successfully.

[5] Borden's Compregnite (Phenol-Formaldehyde).

Included for comparison in Table 1 are some corresponding values for cross-laminated Sitka spruce compreg. Test results indicate that Douglas-fir flāpreg is slightly lower than Sitka spruce compreg in modulus of rupture and modulus of elasticity. In water absorption after a 24-hour soak, the flāpreg absorbed about one-third as much water as did compreg.

Flāpreg, in common with compreg, can be readily worked with high-speed steel or carbide tools. It sands easily, takes a high polish, and needs no varnish or other finish for most applications.

Screw-holding, either in face or edge, is excellent with machine screws in tapped holes or with self-tapping machine screws. The material is very resistant to acids and organic solvents. It is attacked slowly by strong alkali. In the higher densities it is completely cigarette-burn proof: the only effect from a burning cigarette is a brown stain of condensed tars, which is easily wiped off with an organic solvent.

Table 1.—COMPARISON OF PHYSICAL PROPERTIES OF DOUGLAS-FIR FLAPREG AND SITKA SPRUCE COMPREG

	Douglas-fir flapreg (Random orientation)				Sitka spruce compreg[1] (Cross laminated)			
	No. of tests	Minimum	Maximum	Average	No. of tests	Minimum	Maximum	Average
Specific gravity	8	1.39	1.39	1.39	8	1.32	1.36	1.34
Modulus of rupture (psi)	8	12,100	13,700	13,170	8	14,610	16,360	15,240
Modulus of elasticity (psi)	8	1,690,000	2,140,000	1,910,000	8	2,262,000	2,343,000	2,290,000
Internal bond (psi)	6	912	1,188	1,097				
Thickness swell % 24-hour water-soak	8	0.2	0.8	0.42				
Water absorption % 24-hour water-soak	8	0.41	0.50	0.44	6	1.41	1.54	1.46

[1] Erickson, E. C. O., 1952 mechanical properties of laminated modified wood, U. S. Forest Prod. Lab. Report R1639 Rev.

Strong joinings can be made with chemo-setting adhesives such as the epoxy resins, but the impermeability of Flāpreg prevents the use of adhesives with volatile solvents.

Variations of the Process

The basic flāpreg process as described above can be varied in many ways to produce materials for different end uses. A few of these possibilities will be discussed to suggest the flexibility of the process.

Lower Density "Impreg" type Board: While maximum resistance to water absorption is achieved by complete compression and elimination of all air voids, the resulting high density (1.4) is a disadvantage in some applications. A carveable, glueable, product of medium density with high dimensional stability can be made by pressing at lower pressure. To maintain high internal bond strength, it is well to use about 5 per cent of a higher molecular weight bonding-type resin in addition to the impregnating resin. This can be sprayed on to the previously impregnated and dryed flakes, or it can be mixed with the impregnating resin. In the latter case, the temperature in the re-drying step must be very carefully controlled to prevent pre-cure of the bonding resin. A continuous range of densities is available by this method from about 20 per cent greater than that of the wood species used to 1.4.

Also, if less than maximum stabilization can be tolerated, costs can be lowered by use of less than saturating amounts of impregnating resin. In this case, it is always necessary to use additional bonding resin, because no significant bonding can be achieved with impregnating resin alone in less than saturating amounts, even with full compression.

The combination of these two variables of specific gravity and degree of impregnation makes available a two-dimensional continuum of products ranging from ordinary low-density, unimpregnated flakeboard at one extreme to the fully-impregnated and compressed flāpreg at the other. The details of much of this field have yet to be explored.

Three-Layer Boards in One Pressing: Another approach to lower density and lower costs is through the use of an integral three-layer construction with fully impregnated and compressed flāpreg surfaces over a lighter, cheaper core. This possibility of a considerable density difference between surface and core is afforded by the differences in compressibility of wood flakes with various resin treatments.

Table 2.—VARIATIONS POSSIBLE IN DIFFERENT LAYERS OF THE SAME BOARD

	Wood species	Resin treatment of flakes	Characteristics	Sp. G.
1	Redwood	40% "Compregnite" impregnating resin	Hard, dense, prefinished, impermeable wearing surface	1.30
2	Doug.-fir	5% phenolic bonding resin	Low density, high strength, high impact strength, low-cost core material	0.80
3	Doug.-fir	30% "Compregnite" precured in dryer, then 5% bonding resin	Low-density core with high dimensional stability	0.64

Three examples are given in Table 2 to show board densities that result from different resin treatments, all made at the same press temperature, pressure, and moisture content, (300° F, 500 psi, 10% MC) and thus being simultaneously achieveable in different layers of the same board.

Such three-layer boards with unimpregnated flake core material should be adaptable to wall paneling, furniture panels and tops, and counter and table tops where the edges can be protected from moisture. Lower over-all density, with greater dimensional stability but at greater cost, would result from the use of the third type of material for the core.

Variable Density in Different Areas of the Sheet: Mat thickness can be varied to produce high-density sections, accordingly, in predetermined locations in a board. Thus local areas can have increased density and strength to receive fasteners or resist other concentrated loads. Table or counter tops could have edges of increased density and strength.

Oriented Flagreg: Directional properties similar to parallel-laminated compreg and impreg can be achieved by the use of long narrow flakes, which are amenable to orientation in the felting operation.

Other Resins: Cresylic acid-formaldehyde resins can be substituted for phenol-formaldehyde resins to reduce cost. Flāpreg boards with physical properties at least equal to straight phenolic flāpreg have been produced with both a commercial phenolic cresylic combination resin[6] as well as a straight cresylic resin formulated by the Chemistry Section of the W. S. C. Industrial Research Division. Savings in resin cost up to 30 per cent appear to be possible by these means.

Other Particle Types: While flake-type particles give the highest strength properties, any wood particle with either a thickness perpendicular to the grain of about 0.02 inch or less, or a length parallel to the grain of about 1/8 inch or less can be completely impregnated by spray application of resin. This refers to Douglas-fir. For more easily impregnated woods, these critical dimensions would be correspondingly larger.

Fully impregnated and compressed flāpreg has been produced from fractions of both green and dry planer shavings of Douglas-fir and Southern yellow pine. These fractions were prepared by air classification to remove the heavier particles.

Small, granular particles impart considerable flow to the mixture and should be useable in molding more complex articles than could be molded from flakes alone.

Suggested Uses

Flāpreg in board or sheet form should be an excellent material for table, counter, and furniture tops, cutting boards, shelves, floor tile, wall paneling, and electrical insulation.

Flāpreg, machined to final form, should find use in electrical parts, gears, cams, metal spinning chucks, patterns, punch and die sets for sheet metal forming, cutlery handles, saw handles, golf club heads, and brush handles.

In molded form, flāpreg should be adaptable to trays, drain boards, chair seats and backs, toilet seats, and other simple shapes that do not require much flow.

Discussion

K. N. Stordalen (Wynnewood Products): Do you have any cost figures for 3/4 inch board per thousand square feet?

Mr. Talbott: Of course there has been only laboratory-scale production so far, but we estimate commercial production costs at about $1 per square foot for 3/4 inch material.

J. Allan Hauter (Allan Products Co.): What type and what percentage of resin is used?

Mr. Talbott: Phenolic resin at about 30 to 35 per cent resin solids.

C. R. Sutor (Aetna Plywood & Veneer Co.): Most board materials tend to warp under humid conditions. Have you studied this phase of the material?

Mr. Talbott: Because of the very slow changes in moisture content in this material, detailed studies of warping have not yet been made. However, we have not encountered any warping problems.

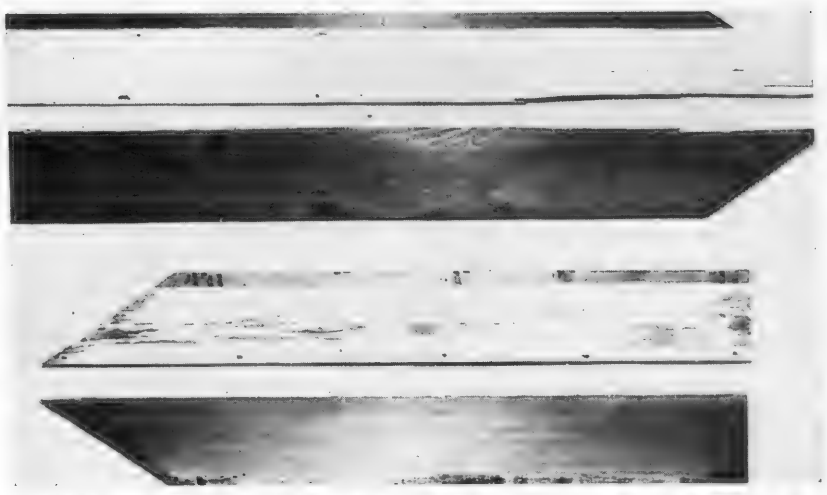
[6] Borden's Cascophen X–405–123 phenol-cresol-formaldehyde rein.

EFFECTS OF WOOD ON

Durability of Finishes[1]

D. F. LAUGHNAN
Paint Chemist, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Exterior wood surfaces are finished mainly for decoration. The three classes are: natural finishes, stains, and paints. Film-forming types retard moisture, protect against weather. Penetrating stains offer much less protection.



Typical paint failures on flat-grain boards. Photo shows front and back of each board to illustrate flat-grain pattern.

WEATHERING OF WOOD IS DUE partly to physical and partly to chemical changes in the wood. (1).[3] The physical changes result from repeated unequal swelling and shrinking that accompany wetting and drying of exposed wood surfaces. These changes occur with the ever-changing humidity of the asmosphere and, of course, with rain and sunshine. The surface layers of wood respond very quickly to these changes, but the inner portion of the wood lags behind because of the relatively slow rate of diffusion of moisture in wood. This lag tends to keep the interior at a relatively uniform moisture content and constant volume, so that when the outside wood fibers swell and shrink they are alternately squeezed together and pulled apart. Moreover, there are inequalities in the surface layers themselves because the dense summerwood swells and shrinks more than the lighter weight springwood.

The chemical changes result from the action of sunlight, air, and water on the surface layers of the wood. A gray layer develops on the exposed surface, and a brown layer immediaely beneath it. Lignin becomes soluble and is leached from the gray layer and less nearly completely from the brown layer. The more easily hydrolyzed portions of the cellulose are lost in much the same way.

The combination of physical and chemical changes causes a very slow breaking down and wearing away of the surface fibers, and more noticeably in grain raising, checking, cracking, splitting, cupping, warping, and pulling at fastenings. The wearing away of wood from the surface progresses at a rate of about ¼ inch in a century.

Decay is a more serious deteriorating factor in wood that is not properly used or protected. It is caused by the action of wood-destroying fungi-small living organisms that actually feed on the wood substance. The visible effect is familiar to everyone as "rotten" wood. The fungi can grow only at times when the wood is damp or wet. Decay therefore requires longer periods of dampness than are necessary for weathering, but when such conditions prevail, decay destroys wood far more rapidly than weathering does. Weathering and decay are not usually found in the same place.

Weathering may occur though the wood as a whole remains fairly dry. The surface layers of the wood periodically take up moisture, but drying occurs before the water can penetrate to the interior of the wood and thus support decay. Wood kept well above the ground seldom decays unless joints in the structure admit water that is retained in the wood for relatively long periods of time.

Protection against weathering can be provided by coatings of paint or varnish. Such coatings, though they are not impermeable to moisture, prevent rapid changes of moisture content in the surface layers of the wood and thereby prevent weathering. Coatings do not preserve wood.

Where decay is likely to occur, the heartwood of a naturally durable wood should be selected, or if either a nondurable wood or mixed heart and sapwood of any wood is used, it should be impregnated with a preservative. Oil-borne as well as water-borne preservatives are available. Some of the more common oil-borne preservatives are creosote, pentachlorophenol, copper naphthenate, and the organic mercurial compounds. The waterborne

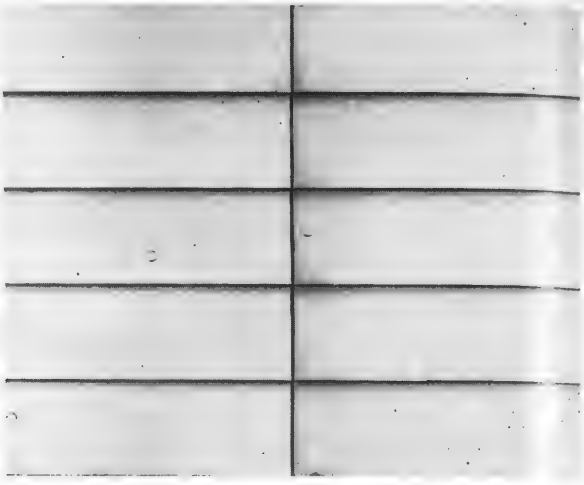
[1] Presented at the May 1958 meeting of the Northern California Section, FPRS, at Berkeley, Cal.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to the Literature Cited at the end of this report.

The Author: Don Laughnan holds a BS in chemistry from the University of Wisconsin. He is head of the Painting and Finishing Section at the FPL, and is vice-chairman of the FPRS Wood Finishing Division.

With no finish at all, wood weathers about ¼ inch per century.



Typically good paint coating on vertical-grain wood.

preservatives include zinc chloride, chromated as well as copperized chromated zinc chloride, chromated zinc and copper arsenates.

In the New England area and in other areas of the country, there are wood buildings more than 250 years old that were never painted (2). It is apparent from this and other evidence that wood is a durable building material and, in fact, is commonly referred to as a permanent building material. Wood will, on its own, outlast many, many times the most durable paint. It should be obvious, then, that we could not economically paint wood for the sole purpose of protecting it. On a dollar-and-cents basis, we would be far ahead to give wood siding, for example, no protection and simply replace it when it wore out.

Improving the Appearance of Wood by Paints and Finishes

Although wood may be used for exterior surfaces with satisfactory results without the benefit of protection from paint or other finish, if proper precautions are taken in selecting and using the wood, the exteriors of few wood buildings are treated in this manner. Weatherbeaten wood is well adapted only to a limited number of architectural designs and to rustic settings, and most of us prefer the appearance of painted or otherwise finished wood. Therefore we paint or finish exterior wood surfaces to decorate them. The protection afforded by the finish is of secondary importance, if it is considered at all.

One should give careful consideration to selecting the finish. Equally important is the selection of the wood that will best meet the requirements.

Factors That Affect the Serviceability of Finishes

Some species of wood hold coatings longer and better than do others. Even within an individual species, some boards hold coatings longer than others. The properties of wood that affect coatings are density and texture; content of resin, oils, water-soluble extractives, and moisture; and defects such as knots and pitch pockets. (3)

Among softwoods, the finishing characteristics depend primarily upon the amount and distribution of summerwood. The oils of which finishes are made penetrate farther into summerwood than into springwood but, in doing so, generally become separated from the coating and therefore do not help hold the coating in place. (4) New or young coatings adhere firmly to both springwood and summerwood, but they come loose from the summerwood with increasing age and brittleness long before they separate from the springwood. If the summerwood bands are sufficiently narrow, a coating may bridge over the summerwood and remain in place, but this will not happen if the bands are wide. Therefore, boards with narrow bands of summerwood are best for painting.

The width of the summerwood bands in softwoods varies with the density of the wood and the rate of tree growth; they are narrower when the density is low or the tree growth is slow. The density of softwood lumber is low when the proportion of summerwood is small. If a tree grew slowly, though, the bands of summerwood may be narrow even if the density is fairly high, because there will then be many growth rings per inch of radius of the log.

The manner in which boards are cut from a log also affects the width of the summerwood bands exposed on the surface to be painted or otherwise finished. Edge-grain boards have narrower bands of exposed summerwood than do flat-grain boards, because they are cut from the log at right angles to the growth rings and only the edges of the growth rings appear on the surface to be finished. In flat-grain boards, which are cut tangentially with the rings, the faces of the growth rings appear. With such boards the bark side invariably hold coatings better and longer than does the pith side.

The wood of hardwoods differs structurally from that of softwoods principally in that it has fibers and pores. The size and arrangement of the pores govern the finishing characteristics of the wood. Hardwoods with pores larger than those of birch are not well adapted to painting or finishing with other exterior surface coatings, because such coatings do not level and fill the large pores. The appearance of the coating on such woods is not as good as it might be, and early failure of the coating is likely to start over the pores. The best hardwoods for exterior finishing are those of low to medium density with pores no larger than those in birch, such as yellow-poplar, aspen, and basswood.

In addition to ash-forming minerals, lignin, and cellulose, the extractives must be considered as a major component of wood (5). The extractives are not part of the wood structure, but they contribute to such properties as color, odor, taste, and resistance to decay, and some affect the finish-holding ability of wood. The extractives include oils, resins, fats, waxes, tannins, coloring matter, and starch, and can be removed from the wood by neutral solvents such as water, alcohol, benzene, acetone, and ether.

The resins and oils in well-seasoned wood have less effect on finishes than is generally believed. There is an indication that the resin in the pine has a slight adverse effect on the life of paints containing zinc oxide when the latter are applied directly to the wood. This shortcoming can be corrected, however, by using a zinc-free priming paint over which a zinc-oxide-containing

ing paint may be applied without penalty.

The essential oils in cypress and some of the cedars and some of the water-soluble extractives in redwood and redcedar may retard the drying of some finishes, but they prolong the life of most coatings.

In green or poorly dried lumber, however, the resins and oils can cause serious difficulty. Resin may exude when finished wood is warmed by the sun or otherwise, and push through or dislodge the coating. The oils in some unseasoned woods may completely prevent the drying of some coatings.

Sometimes white or light-colored paints become discolored on the dry heartwood of ponderosa and the white pines, but more often on wood that has been only partly dried or has become moist after seasoning. This is due to colored substances in the resin of the heartwood that are apparently soluble in the oils and solvents used in coatings, and are evidently more active when the wood is damp than when it is dry (5).

There are, in western redcedar and redwood, water-soluble extractives that enhance the paint- or finish-holding ability of these woods. These woods also owe their color to these extractives. The concentration of the extractives may vary widely from board to board, and there is no simple method for determining their concentration. The extractives are considered by some to be detrimental, because they can cause discoloration of paint and other finish if water gets back of the siding and leaches the extractives from the wood. This might be considered to be an advantage, however, because the discoloration is a warning that a situation prevails that may, if not corrected, result in more serious consequences than discoloration.

In general, the effect of the extractives in wood is small in comparison with the effects of the physical characteristics.

Wood should always be dried prior to use to a moisture content close to the midpoint between the high and low moisture content it will attain in service (6). For example, wood siding for use in the greater portion of the United States should be dried to a moisture content of about 12 per cent, with a permissible range for individual pieces from 9 to 14 per cent. Finishes will last longest on wood so seasoned. They do not, as a rule, last so long on very dry wood.

Wood with a moisture content of over 20 per cent should not be painted or finished, because there is grave risk of the coating failing by blistering and peeling (7). This is caused by pressure exerted against the back of the coating by expansion of air and water trapped in the wood. Of course, coatings may fail by blistering and peeling even though the coating is applied to dry wood, if the wood subsequently absorbs enough moisture to become thoroughly wet.

Knots frequently produce blemishes in coatings and may cause them to fail (4). The end-grain in the knots of any wood often absorbs so much oil from paint that the paint loses its gloss. In pine lumber, the paint over knots may be discolored by yellow or brown substances exuded from the wood. Both excessive oil absorption and discoloration can be prevented by coating the knots with shellac or other spirit varnish, but only with some risk of premature paint failure as the result of incompatibility. Large knots are likely to crack even after they are painted. In general, knotty wood might better be finished with a stain or a penetrating natural finish than with a surface coating.

Pitch streaks or pitch pockets in wood often exude resin, which may either work through ruptures in the paint film or, if none are present, may dislodge the paint film (4).

Blue stain is another defect in wood that can be concealed by paint, provided the wood can be kept dry. If the wood becomes damp, the fungi that cause the stain may be reactivated and push through the paint, thereby discoloring it.

Selection of Woods for Finishing Properties

Since finish-holding qualities are affected by the kind of wood, and woods are marketed by species, the easiest method of selecting woods, where finish-holding ability is a primary requisite, is by species. Species alone, however, is not a satisfactory or reliable basis for selection because of the wide variations in finishing characteristics among boards of any given species. Lumber of the higher grades from the commercially important native woods has been classified by the Forest Products Laboratory for painting characteristics (exterior finishing) into five groups (3, 4):

Group I: The cedars, baldcypress, and redwood, all of which are softwoods. Woods of group I hold all the common kinds of house and barn paints well.

Group II: Eastern white pine, sugar pine, and western white pine, all of which are softwoods. On woods of group II, paints containing zinc oxide, particularly if applied directly to the wood, are slightly less durable, but other paints are as durable as on woods of group I.

Group III: The softwoods white fir, the hemlocks, ponderosa pine, and the spruces; and the hardwoods aspen, basswood, cottonwood, magnolia, and yellow-poplar. Paints deteriorate somewhat more rapidly on woods of group III than on woods of groups I and II. On ponderosa pine, paints containing zinc oxide are less durable than paints free from it.

Group IV: The softwoods Douglas-fir, southern yellow pine, and western larch; and the hardwoods beech, birch, the gums, and maple. Paints deteriorate more rapidly on woods of group IV than on woods of groups I, II, and III. On southern yellow pine, paints containing zinc oxide are less durable than paints free from it.

Group V: Ash, chestnut, elm, hickory, oak, and walnut, all hardwoods with large pores. Woods of group V require wood filler to fill the pores before smooth coatings of paint or enamel can be applied.

In softwood lumber, the better grades for finishing are the select grades. This classification applies to the select grades and affords comparison of the various species only in equivalent grades.

This classification makes it possible to select the best woods for the purpose when paintability or finishability is the dominant consideration in choice. Generally, however, the paintability of the wood is only one of the factors that will determine its serviceability. Other matters must also be considered in deciding upon the kind of wood to use in a given case. Even when it is possible to select the most satisfactory wood, it is imperative that it be used properly, that the finish be of suitable type and quality, and that it be applied and maintained in keeping with the climatic and local conditions under which it must serve.

Literature Cited

1. U. S. Forest Products Laboratory. 1956. Weathering and decay. Forest Prod. Lab. Tech. Note No. 221. Revised.
2. Browne, F. L. 1952. Wood siding left to weather naturally. Architectural Record 112(5): 197–199.
3. Browne, F. L. 1951. Wood properties that affect paint performance. Forest Prod. Lab. Report No. 1053.
4. U. S. Department of Agriculture. 1947. Wood properties and paint durability. Misc. Pub. No. 629.
5. Browne, F. L. and R. C. Rietz. 1949. Exudation of pitch and oils in wood. Forest Prod. Lab. Report No. 1735.
6. Peck, E. C. 1947. Moisture content of wood in use. USDA pub.
7. U. S. Department of Agriculture. 1955. Painting and finishing wood. Wood Handbook, pp. 351–379.

A NEW LOOK AT THE UNDERGRADUATE

Curriculum in Wood Products

D. B. Richards, W. B. DeVall, and J. L. Hill
Forestry Department, Alabama Polytechnic Institute, Auburn

In setting up a curriculum, several points should be kept in mind: the student is investing money and years of his life, and therefore has certain rights of his own; a curriculum is always 5 or 6 years old before its first student is graduated; and it should not be assumed that the "typical" student will not attend graduate school.

AN UNDERGRADUATE CURRICULUM in the field of wood products must guarantee the student an opportunity for a well-balanced education, provide him with the professional know-how to do a technical job, and allow him to develop as a citizen.

These objectives must be attained within a period of four years. Any committee or individual charged with evaluating an existing cirriculum or making revisions that will keep training current with advances in knowledge has a challenging assignment. Certain criteria against which each proposed change may be evaluated must be established. Some of the criteria that educators have established for this evaluation process prescribe that the curriculum should be broad yet intensive, should prepare the graduate for his first job as well as for later executive leadership. It should require college-level competence, yet not be too difficult for the less-than-brilliant student. Some flexibility should be provided to accommodate the individual student's interest, yet not allow him to make the mistake of choosing only the easy electives. The curriculum should prepare the student for graduate study as well as for immediate employment. It should develop the student's abilities to solve problems, to do independent thinking, and to produce on-the-job results.

Forest products curricula have been devised to meet all of the criteria, at least within limits. Most curricula have been characterized by few electives, numerous required courses of technical nature, and considerable laboratory time devoted to vocational-type training. Even if all desirable criteria are met and all undesirable characteristics are overcome, two basic problems may still exist. First, the student may decide to change his major after one or two years. Normally, this involves sacrifice of some credits earned in highly specialized courses. Second, the graduate may find employment in a field other than one directly related to his major. This also involves sacrifice of specailized training.

The curriculum presented in this paper is not faultless. It was designed with the objective of supplying the wood-processing industry, schools, and research organizations with capable, technically trained college graduates. Each graduate would qualify as an educated person. In addition to having technical competence, each would have had training to help develop administrative abilities (including the ability to deal intelligently with people). The foregoing objective is not unique. The committee agreed to avoid being influenced by traditional concepts of curriculum revision. It attempted to establish a floor for the weak student, and to eliminate any ceiling that might inhibit the attainments of the strong student. The committee is confident that conscientious administration of the program will prevent any student from scheduling a substandard program.

In the course of its work, the committee studied both technical and liberal arts curricula of various schools across the country. Individual members of the committee engaged in detailed studies of such matters as the utility of logic courses in developing problem-solving ability, and the possibilities of reducing the course requirements in wood products by condensation and rearrangement.

The New Curriculum

After many changes and compromises, the curriculum outlined in Table 1 was developed. It is offered only as an example of a revised curriculum, and not with the idea that it will meet the needs of some school other than the Alabama Polytechnic Institute.

The first two years of the new curriculum consist largely of English and basic science. They are the same as the corresponding two years of the forest management curriculum, except for deletion of geology, plant physiology, soils and silvics, and addition of analytic geometry and qualitative analysis. The substitution of summer work experience for summer camp, though new at Auburn, is a well-established practice in a number of schools. The junior and senior years are conspicuous mainly for the small number of required technical courses. Except for Wood Technology I, II, and III, the courses are self explanatory. Wood Technology I is a basic course in growth, structure, and identification of wood. Wood Technology II deals with the physical and chemical nature of wood. Wood Technology III deals with mechanics and design of wood structures. Forest Research is a beginning course in statistics.

The student has 57 credits[2] of elec-

[1] Presented at Session VI, Industry-Education, FPRS 12th National Meeting, held June 22–27, 1958, in Madison, Wis.

The Authors: Boyd Richards received his BS in forestry from Colorado A & M, and his MS and PhD from New York State College of Forestry. He was a wood technologist with the Lilly Co. before joining API, where he is now a research professor.

Wilber DeVall holds a BS from the New York State College of Forestry, and an MS from the University of Florida. He is now Head of the Forestry Department.

John Hill received his BS from Colorado State University, and his MF and DF degrees from Yale. He was an instructor at Michigan State before joining API, and is now on the technical promotion staff of NLMA.

[2] The term credit refers to one hour of lectures or 3 hours of lab a week for 11 weeks (one quarter).

tives if he meets the minimum requirement of 216 credits for graduation. If he chooses to take 20 credits each quarter (total of 240 credits for graduation), he may have 81 elective credits. These 57 or more hours of electives can be used by the student to complete the required two minors and to fulfill other personal objectives.

Since success of this program depends on wise use of two minors, some discussion of them is in order. While they are much more flexible than the rigidly prescribed options of some technical schools, they have as their object the student's attainment of reasonable proficiency in the chosen disciplines. The 20 credits at the sophomore level or higher is considered a bare minimum. In many cases, 25 or more credits will be needed.

Since it is the student's attainment of proficiency, rather than the mere accumulation of credit, that is the goal of a minor, the student is allowed to include required sophomore courses in a minor. He is also allowed to omit a normally required course if he covers the same subject matter more thoroughly in his advanced courses. How all three of these ideas work is shown by the following suggested program for a student who wants to minor in chemistry and in industrial management. To attain a reasonable proficiency in industrial management at Auburn, he would have to take 25 credits in that field. In chemistry he would need at least one course in quantitative analysis and a comprehensive organic chemistry course. To get the latter, he could omit CH203 Organic Chemistry (an abbreviated course, normally required) and substitute for it the two-quarter sequence CH207 and CH208, a more thorough and difficult organic chemistry course. He could complete the minor with CH205 Qualitative Analysis (which he was required to take) and CH206 Quantitative Analysis. Thus, his chemistry minor would take only 10 of his elective credits, because CH205 was required anyway and CH203 was omitted. With 25 credits used in the industrial management minor, he would still have a minimum of 22 elective credits (57 minus 35) to use as he wishes.

Perhaps a more nearly typical example would be that of the student who plans to minor in structural engineering. Since two quarters of calculus are prerequisite to his engineering courses, he will probably add two additional mathematics courses, probably differential equations and engineering mathematics, and complete a mathematics minor of 20 credits. His structural engineering minor will consist of four courses: statics, strength of materials, and Theory of Structures I and II. The student would thus have used 40 credits to meet the requirement of his two minors, and would have 17 free elective credits left.

It is clear from the foregoing examples that any student contemplating graduate work would have an opportunity to take at least one year of foreign language. With a slight overload he could readily take two years of foreign language.

Areas for Improvement

In view of the goal to turn out well-rounded graduates, it was originally hoped that an improved sequence in the humanities could be included in the curriculum. This desired sequence was not yet available when the curriculum was being written. It seemed inadvisable, therefore, to crystallize requirements at that time. Enough elective freedom was left to allow the student to take some of the offerings now available in the humanities. With additional experience, the more valuable of these courses might be required.

While the original work of the committee placed considerable emphasis on problem solving, no course by that name is required. It was decided that orderly procedures of problem solving could be encouraged by the manner of presentation of material in regular technical courses within the department. This does not, of course, rule out the possibility of such special courses as scientific reasoning (philosophy) or group discussion (speech), which might be valuable for their contribution to problem solving. At present, however, no such course is required.

The requirement of a senior problem course or undergraduate theses that might encourage the student to develop his special interests as well as to improve his problem-solving ability was considered. This, along with other laudable requirements, however, is omitted in favor of a limited number of required basic courses and considerable elective freedom.

Table 1.—THE NEW CURRICULUM IN WOOD TECHNOLOGY AT THE ALABAMA POLYTECHNIC INSTITUTE

Freshman Year

First Quarter				Second Quarter				Third Quarter			
CH	103	General Chemistry	4	CH	104	General Chemistry	4	EH	101	English Comp.	5
CH	103L	Gen. Chem. Lab.	1	CH	104L	Gen. Chem. Lab.	1	MH	103	Analytical Geometry	5
MH	101	College Algebra	5	MH	102	Trigonometry	5	FY	104	Forest Cartography	2
BY	201	General Botany	5	BY	202	General Botany	5	MS	103	Military Training	1
FY	102	Intro. to Forestry	1	FY	103	Intro. to Forestry	1	PE		Physical Education	1
AS	101	Agr. Orientation	0	MS	102	Military Training	1			Elective	3
MS	101	Military Training	1	PE		Physical Education	1				
PE		Physical Education	1								

Sophomore Year

CE	201	Surveying I	5	EH	304	Tech. Writing	3	CH	205	Qualitative Analysis	5
EH	102	English Comp.	5	PS	205	Intro. Physics	5	FY	204	Mensuration	5
EC	200	Gen. Economics	5	FY	202	Dendrology	3	PS	206	Intro. Physics	5
FY	201	Dendrology	3	MS	202	Military Training	1	MS	203	Military Training	1
MS	201	Military Training	1	PE		Physical Education	1	PE		Physical Education	1
PE		Physical Education	1			Elective	5				

As part of the requirement for the degree with a major in wood technology, the student must satisfactorily complete at least 10 weeks of work experience in a forest products processing plant approved by the department head. A satisfactory written report on this work must be submitted to the department head during the next quarter in residence.

Junior Year

Second Quarter											
EC	213	Eng. Acctg. & Cost Control	5	ZY	101	General Zoology	5	HY	206	American Govt.	5
CH	203	Organic Chemistry	5	SP	305	Public Speaking	3			Elective	15
FY	311	Wood Technology I	5	FY	308	Lumber Manuf.	3				
		Elective	3			Elective	5				

Senior Year

FY	426	Wood Prod. & Mktg.	3	FY	430	Wood Technology II	5	FY	431	Wood Technology III	5
FY	425	Wood Glue & Lami.	5	FY	432	Seasoning & Pres.	5	FY	421	Forest Research	3
		Elective	10			Elective	6	FY	433	Seasoning & Pres. Lab.	2
										Elective	10

Total—216 Quarter Hours

Note: Sufficient latitude is allowed that the student may plan his elective work to fulfill his personal objectives while in college. Two minors will be required however, outside the Department of Forestry. One must be in the School of Engineering or the School of Chemistry. Each minor shall consist of at least 20 quarter hours in a specialized field, in courses numbered 200 or above. (Prior to registration for the second quarter of the junior year the planned course content of the two minors must be approved by the department head.) A student may always substitute a more intensive group of courses for one or more of the required courses, provided the same breadth of coverage is maintained.

Suggested Minors: Engineering Mechanics, Structural Engineering, Mathematics, Industrial Management, Botony, and Chemistry.

An obvious feature of the new curriculum is the administrative problem of time required to council students and to review and approve their individual minors. At present, it is believed that the results will be worth the effort. If a large increase in enrollment occurs, this problem will require considerable thought.

If the new forest products curriculum comes up to expectations, revision of the curriculum in forest management along similar lines would be worthy of consideration.

General Suggestions Concerning Curricula

It would be difficult to terminate this discussion without making certain observations and suggestions concerning the revision of curricula. It is hoped that they will keep us all, including the authors, from thinking we have at last devised the perfect curriculum in wood products.

1. It should be remembered that the student is an individual who has certain rights and interests of his own. He spends about $4,000 and four years of his life to get a degree. It is the duty of the school not only to see that he does not get less than his money's worth, but also to encourage him to get more than his money's worth while in college.

2. A curriculum is always five or six years old when its finished product, the graduate, is available for employment. (It takes one or two years to revise a curriculum, get it approved and printed in the catalog, and it takes a student four years to complete a new curriculum once it is published.) For this reason, a look ahead is always in order. No prediction for the future is completely reliable, however, so a curriculum should be well founded on basic subjects that do not change in value. Furthemore, it should have adequate provisions for flexibility.

3. Needless proliferation of either curricula or course offering is unwise. This same argument could, of course, be used to question the desirability of offering a wood products curriculum. The necessity for such a curriculum stems from the inability or the refusal of most engineers and chemists to understand and deal with the variation inherent in a biological material such as wood. The needed degree of specialization assuredly will be the subject of considerable argument. A very highly specialized curriculum presupposes a knowledge of where the student will find employment plus a detailed knowledge of exactly what training he needs for the job. Past experience indicates this knowledge is not easy to obtain.

4. It should not be faithfully assumed that the "typical student" cannot or will not attend graduate school. The present sad plight of the secondary schools of this country is perhaps in part due to the assumption that the "typical high school student" will not attend college. The capable college student should not have his program so cluttered with vocational courses that he cannot take a foreign language or an upper-division mathematics course if he so desires.

Discussion

The discussion that followed the presentation of this paper and the paper by Jayne and Wellwood, is printed after the latter paper, which follows.

Educating the Wood Technologist[1]

FOR RESEARCH AND SERVICE

B. A. Jayne and R. W. Wellwood
Assistant Professor and Visiting Professor,[2] School of Forestry,
Yale University, New Haven, Conn.

The plan proposed here emphasizes the basic and applied sciences within the matrix of a liberal education, with only moderate instruction in the technological aspects of wood. The goal is to produce intellectually mature technologists suited for industry, yet thoroughly indoctrinated in the basic and applied sciences for advanced research training.

SINCE THE INITIATION of higher education in forest products technology, the diversity of curricula is evidence of the lack of agreement on the basic objectives of undergraduate and graduate preparation. The formation of the Forest Products Research Society has provided leaders in the fields of both education and industry with a medium for the exchange of ideas and beliefs on proper training for wood technologists.

Numerous opinions have been expressed and a wide variety of ideas proposed, in the literature and at subsequent forums. Some have advocated highly specialized programs because of the seeming necessity for training the student in restricted phases of the ever-broadening field of forest products technology. Need for such programs has been felt in particular by a few of the more specialized wood-using industries. Others have argued that the education of the forest products technologist should have its roots in the basic sciences and humanities. Presumably specialization, where needed, would be relegated to graduate education or to a form of on-the-job self-education.

Many educators and industrialists, concerned with trends in higher education, have advocated a broadening of

The Authors: Ben Jayne graduated with a BSF from the University of Idaho. He then received MF and DF degrees from Yale. Jayne was the 1955 Wood Award winner.
Robert Wellwood did his undergraduate work at the University of British Columbia. He then received MF and PhD degrees from Duke University.

[1] Presented at Session VI, Industry–Education, FPRS 12th National Meeting, held June 22–27, 1958, in Madison, Wis.
[2] Professor Wellwood has now returned to his position on the Faculty of Forestry, University of British Columbia, Vancouver, B. C.

curricula to include humanistic-social studies in the training of the technologist. The more broadminded have recognized the need for thorough coverage of both these areas of learning, but are overwhelmed by the task of making space available for new subject matter in already over-crowded curricula.

Is it possible through readjustments, integration, and condensation, foreseeing the risk of abbreviated technical education, to coalesce these seemingly conflicting viewpoints into one general plan? Can a scheme of education be devised that would not only lay the foundation of the basic as well as applied researcher, but also train the service technologist for the wood-using and allied industries? Any plan formulated must then be broad and at the same time contain elements of specialization; it must have its origin in the basic sciences and yet point the way to application of these disciplines. Above all, it must bring into focus the position of the technologist in the over-all cultural matrix through liberal use of humanistic-social studies.

It is the authors belief that a basic scheme of education can and should be devised that will serve as the solid core of training for all wood technologists, irrespective of specific interests. Such a training program must of necessity encompass the aims of higher education. Not only is this vital for the existence of standards within the university, but it is requisite to provide the trained leaders for our industries. These industries have an equal obligation toward education, since in large measure they owe their origin, growth, and continued expansion to the products of our educational system.

The basic concerns of higher education are clear. They are to develop capable and learned individuals; individuals capable of assuming a position of responsibility in the community of educated men, of communicating effectively through the medium of writing and speaking, and of self-education to insure continued intellectual development beyond the confines of a four-year education. Education must instill the desire to excell. It must develop a sense of integrity and the ability for clear and concise thinking, thorough understanding, association, development of memory, and the use of existing facts. It should plant the seeds of creativity, for professional growth in many fields of endeavor flourishes on this ability.

The importance of the communicative skills and the capacity for self-education cannot be overemphasized. Their foundations are laid by means of effective training in speech, writing, and reading. There are no substitutes for these skills. But this training cannot be confined to the four to eight years of student residence at the university; it must continue throughout life. This continuity is assured by the development of the ability for self-education. Such training is requisite for a learned individual, one who is aware of man's social nature, environment, and history, and who possesses a knowledge of basic physical and biological phenomena. He also has a sense of appreciation for the arts and literature, a characteristic just as important to the scientist as to the liberally educated person. In the undergraduate program, his preparation may show some signs of specialization but only to an extent that does not sacrifice the over-all objectives stated.

These aims must be the goal of higher education irrespective of the particular curriculum. The training of the forest products technologist is no exception. Broad and rigorous as these aims may appear, they are designed primarily for the student to gain intellectual maturity, for it is recognized that the mature student is better equipped to master the subject matter of many technical fields. The wood technologist training for service in industry builds on intellectual maturity by means of a moderate number of technological courses, self-education following undergraduate training, and possibly graduate study. The research technologist, in undergraduate but particularly graduate training, must shape a further set of characteristics peculiar to himself, yet qualities that grow out of intellectual maturity.

A researcher, whether in the basic or applied sciences, must possess an analytical and inquiring mind. This is not necessarily a quality peculiar to the research scientist, but it is one without which his capabilities are extremely limited. In large measure it is a natural trait that is furthered by proper education. He must have the desire to understand the fundamental laws that govern physical phenomena. He must acquire the ability to use mathematical equations to explain clearly and concisely, and at times predict, the behavior of a physical system. He will be familiar with experimental methods and, in addition, should develop a certain amount of manual dexterity so that he can devise experimental apparatus. Finally, he must possess the ability to convey findings to his colleagues through effective writing and speech, taking fullest advantage of mathematical and graphical techniques.

It is beyond reason to think that the foregoing can be fully realized in the four to eight years of university education. Admittedly, these qualities of the individual should take rudimentary shape in his training before college years. It is the responsibility of the university to recognize these traits, to further their development, and to provide the stimulus for their continued growth. This can best be accomplished by means of a liberalized scheme of technical education, one in which courses in the basic sciences, technology, and humanities are taught as a continuum. Unity within and between courses of instruction should be sought at all times, for true education is not the accumulation of unrelated scraps of information but an integration of all forms of learning. The training of the wood technologist, when viewed in this perspective, can be most fully accomplished through strong emphasis of fundamentals in both the sciences and humanities.

The Undergraduate Program

The following paragraphs set forth what are felt to be the more important contents of undergraduate curricula in forest products technology. General levels of attainment in each area of training have been included, and in some instances where it seemed important, the nature of instruction defined.

Humanistic-social Studies: Fulfillment of the objectives of higher education is largely dependent on training the student receives in this area of study. An individual capable of accepting a position of responsibility in the community must possess elementary competence in many areas of the humanities. Knowledge of some of the more intangible concepts of art and philosophy are as important to him as a thorough grounding in economics, history, and literature. His initial training to communicate stems from courses in speech and writing. The individual's ability to think, to evaluate, to judge, and to participate effectively in society should originate in the humanities. A working knowledge of foreign languages also comes within this sphere of training.

Many educational needs can be satisfied through competent instruction in English, selected foreign languages, history, and the fine arts. Instruction in economics, business methods, accounting, and industrial psychology may also be important in the development of the wood technologist. In many instances, however, this type of training can be just as technical as that of the physical or biological sciences. It is outside this area that humanistic-social training should occur.

In many technical fields, the broadening of undergraduates has been left to a few random courses of instruction in the humanities and social studies, often selected to fit timetables rather than needs. For the most part it has been left to the student to recognize the significance and application of this knowledge in his own field of endeavor. This system of uncoordinated education is not sufficient to develop the full capacity of the future technologist. The student should be made aware of the significance of technological advancement on civilization, and of the interrelationships of science and the humanities. This atmosphere can be created in forestry schools through the teaching of specialized subject matter in a manner that recognizes its relation to the entire field of modern learning. Training in the humanities would not then be directed toward the solution of specific problems in the technological fields, but toward the broadening of the technologist in this preparation to assume a position of responsibility among educated men.

All recognize that technical competence alone is not enough. Consequently, it is paramount that we provide for the intellectual development of the wood technologist in his specific department as well as in the university as a whole. In large measure, it is this form of education that will provide our future leaders of research and of industry.

Mathematics and Physical Sciences: In our awareness of the rapidly changing state of technology, it is highly desirable to place greatest emphasis on those aspects that will impart the most durable foundation for future development. It is fundamental that we recognize that the status and techniques of present technology are bound to change. Consequently, it is important that training in the sciences consist of elements least likely to obsolesce. Of these, mathematics, physics, and chemistry provide a lasting foundation and at the same time make available a potential for future growth in science and technology.

Recognition of the value of fundamental research in all fields of applied physical sciences has necessitated a thorough grounding of the young scientist in mathematics, which supplies the underlying basis for a complete appreciation of physics and chemistry. Given this background, our wood technology graduates will be equipped to read intelligently in these fields, and materially profit by this reading in the design and solution of experimental problems. Furthermore, it is the key to intelligent understanding of the many known physical and mechanical properties of wood.

In addition to its utilitarian aspects, mathematics affects a thoroughness and directness in the thinking of the applied scientist, two traits that have no substitutes. From the above it is apparent that training in mathematics can further at least two of the characteristics of an educated researcher—the ability to think objectively, and to analyze physical problems in terms of mathematical principles.

One can argue that the present state of development of forest products technology does not justify training to great depths in mathematics. It is not possible for any of us, however, to predict accurately the future growth of this field. Judging from the development of other applied sciences, in all likelihood a more thorough grounding will be desirable in the future.

Competence in the theory and use of ordinary differential equations should be considered the minimum level of acceptability for an adequately trained wood technologist. Advanced study in graduate school should develop competency in higher mathematics, including such areas as differential equations or advanced calculus. It is presupposed that facility in algebra, analytic geometry and elementary statistical methods will be developed by every student.

Whether the wood technologist is considering employment in service or research, a thorough grounding in physics is an indispensable part of his education in the basic sciences. In view of the varied backgrounds of high school graduates, in some instances the future technologist should receive an elementary physics course as an introduction to basic concepts. This type of training, however, is hardly sufficient to provide the breadth and depth necessary for the anticipated future self-education of the graduate in the more advanced topics. An analytical approach to the subject of physics, with thorough indoctrination in mathematical treatments of physical phenomena, is necessary to insure adequate preparation.

It is our belief that the training in physics should come after, or simultaneously with, calculus since an adequate treatment of physical concepts depends to a great extent on the student's mathematical capabilities. As an end in itself, a non-rigorous treatment of physics, in which the student is not instructed in the derivation of equations, will accomplish little toward the preparation of a background for research or service. This training lays the groundwork for a more complete treatment of mechanics, thermodynamics, and courses in instrumentation. Having received the rudiments of higher mathematics concurrently with physics, the wood technologist is equipped to assimilate, with an infinitely better understanding, the more advanced topics of the basic and applied sciences.

An appreciation of the molecular structure of wood, and of the many uses intimately associated with its chemical properties, necessitates at least a rudimentary knowledge of chemistry by the wood technologist. It is preferable that this begin in the first year of college with general inorganic, followed by a second course devoted to the study of organic chemistry. The latter should include treatment of the properties of the broad family of organic compounds as well as an introduction to the concepts of polymer structure and characteristics.

Specialized courses of instruction in wood chemistry, valuable as they may be, should not be substituted for a solid grounding in general organic chemistry. It may be desirable in some instances for the wood technologist to receive instruction in topics such as advanced organic, physical, or polymer chemistry. It is recognized that such training may result in undue specialization of the undergraduate, or may require more time than he has available. Consequently, their inclusion in the program of the graduate school would seem to be more appropriate.

The rigorous training received in mathematics, physics, and chemistry is considered an essential part of the student's indoctrination in most fields of basic as well as applied sciences. The importance of these sciences for the proper education of a wood technologist cannot be over-emphasized. Their relevance is brought into sharp focus when one recognizes that he is working with an organic material, the physical and mechanical properties of which can frequently be expressed by means of mathematical equations.

Botanical Sciences: Even though the training of a wood technologist must lean heavily on the physical sciences, the origin of wood necessitates a broadening of the base to include some of the botanical sciences. A thorough grounding in general botany followed by dendrology, pathology, and instruction in the essentials of wood anatomy and identification, are considered vital for elementary competence in these sciences. Acquaintance with the physiological nature of plants and in particular the tree are likewise essential in his training.

In recent years there has occurred a growing tendency in forestry schools to specialize the training of the undergraduate wood technologist. This has frequently resulted in the adoption of a vocational-type instruction, which in turn has often drastically curtailed treatment of the botanical sciences, both basic and those applied to forestry. It is recognized that greatest emphasis should be placed on the basic physical, and a few of the applied sciences. Vocational-type training may be an essential part of the education of every technologist, but not to the extent that he loses sight of his position in the over-all forestry matrix

Within the framework of the botanical sciences the anatomy and identication of wood serve as introductory courses to wood technology. They also prepare the student for study of advanced topics in the gross and fine structure of wood. As is the case with many forms of the advanced physical sciences, however, it is probable that such training should be relegated to the graduate school.

Applied Sciences: The elementary applied sciences in the curriculum should include mechanics (statics and strength of materials) and thermodynamics—the foundation courses for complete study of the physical, mechanical, and chemical properties of wood. Instruction in mechanics is considered prerequisite to an effective treatment of the mechanical properties of wood in the same light that instruction in the physical properties of wood must also build on the technologist's knowledge of other aspects of applied physics.

The ability of the research technologist to understand and use thermodynamic principles must reach beyond simple powerhouse operation. Training in the fundamental rather than applied concepts of this subject prepares the way for an integration of physics and chemistry, and application of the whole to a better understanding of the properties of wood.

In the applied sciences, a program of training should be sought that makes the fullest use of the student's competence in mathematics, physics, chemistry, and biology. It is unlikely that any of the remaining areas of instruction in wood technology afford an equally suitable opportunity for an integration of scientific training. Considerable repetition of subject-matter instruction may occur in the assimilation of applied sciences; however, repetition is a normal pedagogic method essential to a thorough educational program.

Technological Training: An educational program, fully cognizant of the needs of the research and service wood technologist, will include courses in glued-wood products, wood seasoning and preservation, lumber manufacture, wood fiber products, and such technique courses as drawing, which emphasize practical work. Fundamentals should be emphasized in their presentation in order to coalesce basic scientific and technological training. A fundamental approach to technological subject matter will tend to minimize any vocational emphasis, whereas the teaching of unrelated scraps of information has no place in the sound education of an applied scientist. Vocational-type courses, which are frequently of this kind, have often displaced the basis applied sciences in technological fields. Such courses should be carefully scrutinized in the light of the over-all objective of higher education.

Need for Graduate Training

The proposed training has relied heavily on the basic and applied sciences, with particular emphasis on the necessity of a thorough indoctrination of the student in mathematics, physics, chemistry, and botany. It has also advocated that this foundation should be broadened by including instruction in humanistic-social studies, to provide both the research and service wood technologist with the scope of education requisite of a university graduate.

The wood technologist contemplating service in the wood and allied industries should be adequately prepared to assume a position of moderate responsibility. It is not intended that his preparation should qualify him for a specific position in industry. This is not within the objectives of university education. Rather, it is the responsibility of industry to provide, in large measure, the practical education and orientation of the graduate. At the same time, the industrial wood technologist may benefit greatly by taking graduate training, particularly to the Master's level. In this way he is able to build on his background and thereby will have greater competence and usefulness to his employer.

It is unlikely that the four-year undergraduate will possess the maturity or degree of specialization necessary to conduct independent research. Consequently, some form of advanced study should be sought by the technologist interested in research, preferably through graduate instruction. It is possible that some can attain the desired degree of specialization through actively engaging in reseach projects in industrial, governmental, or university laboratories. If the primary objectives of the undergraduate education have been met, in particular the stimulation of independent thinking and development of the capacity for self-education, the undergraduate is well prepared to further his education toward an ultimate goal of research.

In most instances, the specialization necessary for productive research should take place in a graduate school. At this stage of the technologist's preparation, specialization in any phase of wood or wood products can pay real dividends, for the graduate then has a solid educational foundation on which to build. Areas of study may include advanced topics in mathematics, physics, chemistry, and botany to increase his familiarity with the basic sciencies.

The student is then prepared to undertake special-problem courses often concerned with research on wood or wood products. He should be continually encouraged to utilize fully the background in the applied and basic sciences acquired undergraduate preparation. At this stage in his education, he should be prepared to design, carry out, analyze, and report on technical research projects. The importance of this phase of education cannot be over-emphasized. It is the point in the educational program of an applied scientist at which all forms of preparation can be integrated.

The graduate student is qualified to participate in seminar discussions, which are not only valuable from the standpoint of a free exchange of ideas between the participants, but also serve as a device to sharpen the communicative powers of the student. The seminar should develop the student's ability to prepare a topic on a technical subject and present it in a logical, concise manner. He should be urged to analyze critically the methods and conclusions of other participants, and use the exchange of ideas in the formulation of his own research.

Conclusions

A plan of education has been proposed for the forest products technologist that emphasize the basic and applied sciences within the matrix of a liberal education. It has as its goal the development of an intellectually mature technologist suited for service in industry, yet thoroughly indoctrinated in the basic and applied sciences. It is felt that an education of this form not only prepares the way for good citizenship, future self-education, and effective participation in service, but also lays the groundwork for the advanced training of a research technologist.

It is not proposed that this will pro-

vide the student with every scrap of knowledge necessary for a specific job. Rather, it has been emphasized that this is not the purpose of higher education. The student should acquire fundamentals in all segments of his training that will prepare him to learn for himself in a manner that assures coordination with the entire complex of modern knowledge. If this can be done, we have not only trained an able and effective citizen, but also a technologist capable of a high level of professional competence.

General Discussion

Hugh Angleton (Purdue University) (to Dr. Richards): From your curriculum, if you had two men, one electing chemistry and industrial management and the other electing engineering mechanics and mathematics, wouldn't one be rather poorly prepared for wood technology III and the other rather advanced for that course?

Dr. Richards: That is true, of course. It is impossible to include everything in a curriculum and still provide flexibility. As has already been presented, it is desirable to include differential equations, physical chemistry, and strength of materials, but there is not time in four years. That is perhaps begging the issue in this case. What you are saying is that students coming into a course are different in preparation, which implies a difference in ability to perform in a course.

Mr. Angleton: Yes, I have the same troubles myself. It is frustrating to the instructor.

Dr. Richards: This problem also exists due to difference in native ability. The problem is compounded by difference in preparation. Let's consider two courses. Wood Technology II deals with fluid relations in wood, and other physical and chemical relationships. It is true that a person with more rather than less chemistry is going to understand these things better. In wood technology III a person with an engineering background is going to understand timber mechanics better. Frequently, a course in timber mechanics is taught without calculus as a prerequisite. When this is done, the course cannot be high-powered in the field of mechanics. Some of it has to be descriptive. That is an ever-present problem. You can't bring all students to the same degree of proficiency. But, insofar as the course emphasizes the effects of defects, slope of grain, sapwood and heartwood differences, and so forth, the influence that they have on strength will be new even to the graduate engineer.

B. S. Bryant (U. of Washington) (to Dr. Jayne): I appreciate your philosophy very much, but you made no mention of the need of the wood technologist to become familiar with problems of a forester or to develop a certain forestry mindedness, which I suggest too is an important part of his background if he is to assume the creative place that you have talked about in the forest products industries.

Dr. Jayne: We are aware of some of the shortcomings of this plan of education in all fields of basic or applied science. In the field of general forestry, which is of course highly important to the wood technologist, we have endeavored to strengthen his background by the inclusion of courses in the botanical sciences such as general botany, dendrology, pathology, and plant physiology. Let me emphasize that it is not possible to thoroughly indoctrinate the student in all the surrounding areas of science. We can only hope to awaken his intellectual powers to assure that he will learn for himself in the more specialized areas of each science.

Dr. Wellwood: A partial answer will be found in the paper. Certain aspects of forestry such as silviculture are included in the curriculum.

George Garratt (Yale School of Forestry): This particular discussion points up the fact that educators in forest products and wood technology fields are beginning to face up to certain facts of life that are also confronting educators in general forestry. Today we are all beginning to concern ourselves with the problems of education for a profession rather than training for a vocation. I am reminded of a story about an electrician who seemed to be rather stupid, and kept coming up with questions. Finally, his boss said to him, "Why do you keep coming to me all the time; why don't you use your common sense?" "Sir," he said, "common sense is a rare gift of God, I have but a technical education".

It seems to me that we are at long last trying to do something about that element of common sense, in recognizing some of the elements associated with it. There is one point that I should like to emphasize. We have been talking about curricula. I feel that there are two other equally important elements that must be considered. One of these is the student we admit to our schools. If we are going to set up improved programs of study, such as we are talking about, we should recognize the advisability of limiting our admissions to students fully capable of profiting from such instruction. One place where we have fallen down in our whole educational program has been in admitting into our schools too many men of clearly limited ability, who lack real capacity for technical and professional development.

There is another closely allied problem, if we are going to upgrade our curricula and provide greater opportunities for the better students. This relates to the need for giving considerable thought to the people whose job it is to administer our programs of study, to teach the course, and to provide the guidance that is essential if we are to raise our wood technology and forest products instruction to the level where we want to see it. This faculty approach is essential if we are to educate men for leadership in our profession, rather than contenting ourselves solely with training technicians.

Ellis Cowling (U. S. Forest Products Laboratory): Dr. Jayne, you and Dr. Wellwood have both commented on the importance educators should attach to developing in students a capacity for self education. In what degree do you feel present undergraduate courses accomplish this? In a typical lecture course, for example, subject matter is presented to the student in the form of lectures and assigned readings in a textbook, and in a typical laboratory course the student is provided with a detailed outline that directs him to make and record certain relatively specific observations. How well do you feel such lecture courses train the student to approach the original literature out of which he must obtain information he will need when his professors are no longer available for consultation and his textbook has become obsolete? How well do you feel this kind of laboratory course trains the student to competently design and execute experiments in order to acquire new knowledge on his own?

Dr. Jayne: In essence I believe you are criticizing the current methods of

presenting subject matter to students. He, more often than not, accumulates a vast store of information, but is unable to bring it to bear on a particular problem and is also quite often unable to self-educate himself. I agree with your criticism wholeheartedly. I believe the solution lies not only in a revamping of curricula but also of teaching methods.

J. D. Sullivan (Michigan State U.): I have two questions. Dr. Jayne, do you consider statistics an important fundamental science for wood technology? Dr. Richards, what about the apparent exclusion of statistics from your program?

Dr. Jayne: Considering that wood technology is partially a biological science, I think statistics is important; however, I do not classify it as a fundamental science. It is in fact applied mathematics, and consequently should assume its proper perspective in the curriculum.

Dr. Richards: As I mentioned, one of the titles that is a masking name is Forest Research. That is nothing more or less than a beginning statistics course. It is taught in our own department because we have a staff member who specializes in statistics. This may not be justified in most schools. There may be a comparable course in another department. That course could well be biometry. Statistics has not been left out.

I would like to add a comment on whether statistics is fundamental. It is one of the few things that I might differ with you on, Ben. Not that mere manipulation of a calculator is a fundamental discipline, but that there is a very deep philosophical question involved that many of us at times forget. We go through life making probability statements. I think that somewhere in everyone's philosophy there should be an appreciation of the fact that we are continually making probability statements. In learning about probability it helps to have some knowledge of statistics. Therefore, for philosophical reasons as well as for its utility in experimentation, I would say that some knowledge of statistics and of mathematical probability is basic.

J. R. Stillinger (Cascades Plywood Corp.): I've been hoping that someone other than myself from industry have a comment or a question to ask.

With reference to the questions asked on the necessity of including statistics in the required curriculum as proposed by Dr. Richards, I believe this question can best be answered without too much difficulty if one refers back to one of Dr. Richard's initial remarks. He stated that one of the big problems in dealing with any forest product is that of variability. It would seem to me that this statement in itself justified the inclusion of statistics in the required curriculum.

I would like to ask Dr. Richards to comment on the need of including general zoology in the required curriculum in the junior year. I also noticed the omission of any work in forest pathology.

Next, I would like to ask a general question directed at the speakers as a group. I'm wondering if the student in his junior year has reached the stage of mental development where he is able to make the right selection of the particular minor or minors? I have often asked myself since taking a job in industry if it would not be advisable to take a young man with two or possibly three years of basic college training, even at the exclusion of having a degree, and having him work in industry for two or three years to orient himself with regard to specific field in which he would like to specialize. It would seem to me that the student then would be in a much better position to decide whether he should select a minor in chemistry or engineering. These two particular fields would certainly lead the man into different types of work in industry, and it would be a bit frustrating if that man got into one field and found that he wasn't adapted to it or didn't like the work.

A. J. Panshin (Michigan State U.): I think the question raised is exceedingly important, and I wish a cooperative program with industry were possible. We can't do anything ourselves. Such cooperation would be very desirable.

Dr. Richards: Why zoology? Two reasons. One is we are trying to produce a whole man. I don't think there should be a single college degree in the U. S. given to anybody who hasn't had a course in zoology. Whether the degree is in home economics or English, I think we need to know more about our body, about nutrition, about the theories of evolution, and so on. That is a cultural course as well. If he decides to take entomology, he must have zoology.

The omission of pathology is a good criticism. I didn't want to push a special interest of my own. Some of the most fundamental aspects of pathology could be covered within wood technology and in seasoning and preservation. We hope that some students will elect to take pathology.

A. C. Barefoot (N. C. State College): The emphasis on an increase in amount and quality of basic science instruction in the varied wood curricula raises a question concerning the desirability of converting to five year programs at the undergraduate level. Is there any evidence that this move will materialize? Or will the old argument of competition for students, based on four year programs, effectively block such a change? How can the schools resolve this question of limited time, if a four year curriculum is continued?

R. M. Carter (N. C. State College): In these discussions of wood technology curricula, the tendency to leave "sufficient latitude" for the student to select electives seems to be the accepted trend. Is this tendency a result of not really knowing what should be in the curriculum or is it because the wood field is broad, varying from specialized research to management of a wholly integrated forest products business? I hope and like to believe our basis for elective credits is the latter. If so, then the faculty should guard against the pitfall of allowing the student to select elective credits. To guide faculty advisors in making the proper selection of electives, aptitude and related tests should be utilized.

Dr. Wellwood: Dr. Richards has commented at length on the importance of statistics in the forestry curriculum, both as a mathematical tool and as a fundamental course in philosophy. The place for such a course would seem to be in the sophomore year, so that statistical methods can be used by the student in courses in the junior and senior year. This procedure is followed at the University of British Columbia.

Richards has also discussed the difficulties encountered in teaching an adequate course in timber mechanics to students who have not had calculus. Jayne and Wellwood, in their paper, insist on a thorough background in calculus as prerequisite to a course in timber mechanics that makes full use of the mathematical approach. The above writers also point out that mathematics forms an integral part of the teaching of other courses in wood technology. An incomplete background in mathematics leads to inadequate coverage of such courses. In the second year of the forestry curriculum at the University of British Columbia, calculus is used as an elective and a screening course. Students intending to take either the forest products—wood technology option, or the forest harvesting option, must show competence in calculus before being accepted for further work in either of these options.

Helicopters in British Forests

R. G. SHAW

Machinery Research Officer, Forestry Commission, London, W. 1.

A 600-pound load of forest thinnings being removed dur g British helicopter trials.

THE POSSIBILITY of using helicopters to provide forest transport in inaccessible areas had been under examination for some time, so advantage was taken of the presence of a helicopter in a mountainous forest area. A trial was arranged to establish some facts on the usage of this method of transport. Since extraction is one of the obvious uses of helicopters, the trial was based mainly on this operation, but other possibilities such as direction of fire fighting operations, the carriage of stores for fencing, spraying, and so forth were also considered.

Conditions of the Trial

The aircraft used was an Agusta-Bell 47G, an American design made under license in Italy. The payload is 600 lbs. and the flying speed is 60 mph. The trial took place at Glenduror forest near Fort William in Scotland on October 9, 1956, in perfect weather conditions. Visibility was good and there was no wind.

A quantity of second thinnings had been collected in a clearing roughly 50 yards by 50 yards on level ground at a point 600 feet above and 1500 yards distant from the road point where it was desired to deposit the timber.

Observations

1. The particular aircraft used in this trial was fitted with brackets for the carriage of iron pipes secured horizontally under the fuselage. The forest thinnings were made up into bundles of up to four poles each to be carried in the same way. The aircraft was fitted with a ratchet winch used to pull the load up tight against the brackets.

The original idea for picking up the load had been for the helicopter to hover overhead and drop a winch rope for the load to be hauled up as is done in air–sea rescue operations. This method cannot, however, be used on the small Bell machine because it does not carry the necessary long haul winch. It may, in fact, never be possible to use this method because a hanging load not rigidly secured is not liked by helicopter operators. The load is automatically released as the machine hovers a few feet above the delivery point.

2. Eleven flights were made; they started with loads of 400 lbs. and gradually increased to the full payload capacity of 600 lbs. Each flight was made without the slightest difficulty, and the pilot expressed the view that he could continue indefinitely.

Experience gained during the day suggested that a landing area of 50 yards by 50 yards is greater than is really necessary. The area should be a longer and narrower strip to give a good run in and run out in the direction of the prevailing wind.

On more than one occasion, the machine flew away, delivered the load, and was back again before the next load could be prepared.

3. As experience was gained during the day, the time taken for the complete sequence of operations of loading, flying, delivering at the unloading point, and flying back was reduced to 5 minutes 37 seconds. Of this time, 3 minutes were absorbed in loading. With practice this time could be considerably reduced and it seems reasonable to expect that this machine could extract 3 tons per hour.

The maximum cost that this operation would bear is some 30/-per ton at which rate the machine would be earning £4.10.0 per hour, a figure far below present-day (1956) helicopter operating costs.

4. Various lengths of poles were carried, the longest individual pole being 27 feet. This was a much longer load than had previously been thought possible with this type and size of aircraft.

5. There was no opportunity to find out the maximum gradient on which the helicopter could safely land, but the ease with which the pilot set this machine down in various positions suggested that considerable latitude is permissible.

6. Flights over the forest showed how much can be seen in great detail from a helicopter. The ability to fly and hover close to the tree tops and close to trees growing on a steep hillside enables a far more detailed examination to be made than is possible by any other means.

Spraying and direction of forest fire fighting by wireless could be done with great accuracy. The whole forest drainage plan can be seen, including every point where the flow of water is interrupted.

Conclusions

This trial provided some practical data on the application of small helicopters to certain forest operations. Methods of loading and unloading long poles are now known, and some indication of the carrying rate per hour has also been revealed.

It is quite certain that, although helicopters are extremely convenient for many forest operations, they will not be an economic proposition until their operating costs are reduced far below the present figure.

[1] From report No. 57 of the Headquarters Development Committee, Forestry Commission, London.

Helicopter development will continue to be watched and trials will be resumed if substantially lower operating costs are achieved.

Addendum

Fuller figures of the trials were:

Payload ---------- ¼ ton
No. of journies per hour (1500 yards each way) ---------- 12
Amount carried per hour ---- 3 tons
Helicopter cost per hour ---- £25
Hence the cost per ton is $\frac{£25}{3}$ = .8.3.

£1.5 per ton was taken as the highest cost that the operation would stand, since that is a figure that brings the total cost of selling and extraction uncomfortably close to the selling price on roadside.

Costs were then six times the economic rate, but with the much larger payload aircraft that are now available, the cost per payload ton will fall a very long way, and this year may find us not so very far outside the goal.

Other Developments Around the World

Wood Protection Meeting to be held in Hamburg

The German Society for Wood Research will hold a meeting on Wood Protection in Hamburg, Germany, July 9–10, 1959, in connection with its work committee meetings on July 8th.

Lectures on fundamental problems will be held the first day of the meeting. Practical problems of wood protection and techniques will be discussed the second day. Specialists and interested persons are invited to attend.

Presentation of new research results and experiences on critical reviews of special fields that have not been previously published will be welcome.

Reservations for the meeting will be accepted and confirmed starting the middle of April by the German Society for Wood Research, Stuttgart S, Danneckerstrasse 37, Germany.

Soviet Timber Economics

The Soviet timber industry, and some of the related forest products industries, is the subject of a thesis written by W. Donald Bowles, Asst. Prof. at the American University.

Mr. Bowles is a specialist in economics with a particular interest in Soviet timber and allied industries. In recent correspondence with FPRS, Mr. Bowles indicated that further information can be obtained by writing him at the Dept. of Economics, College of Arts and Sciences, The American University, Washington 16, D. C.

Leloup Retires as Director of FAO Forestry Division

M. Marcel Leloup of France, Director of FAO's Forestry Division since its creation more than 12 years ago, retired at the end of December, 1958. Mr. Egon Glesinger, of Austria, succeeds Mr. Leloup as Director of the Division of Forestry and Forest Products, the new title of the Forestry Division. These changes in personnel and name went into effect January 1, 1959. Mr. Glesinger is also Director of the Timber Division of the United Nations Economic Commission for Europe.

Scanning World Wide Forest Products Publications

The Use of Carbide Tipped Milling Tools with Limited Depth of Cut in the Woodworking Industry. Hermann Haidt. *Holz a. R. uW.* V. 16, No. 8. (In German)

Demand and competition force all factories to save, more than ever, production time and production costs. A definite step towards the achievement of this aim is the application of carbide-tipped tools with a long service life and a high efficiency in removing chips. Rationalization measures and automation in the wood-working industry necessitate the application of these tools in order to achieve high results and, at the same time, shorten the production time. The article deals with the latest developments of carbide-tipped tools for woodworking machines. The preliminary conditions for the use of these tools, their applicability, and their attendance are explained in detail.

Some Critical Reflections on the Analysis of Woods. Karl Kürschner. *Holz a. r. uW.* V. 16, No. 8. (In German)

Dealing with the Kürschner-Hoffer method for the analysis of cellulose, a short survey is given on the significance of "pure cellulose" and "wood cellulose" in lignified membranes. A discussion of several proposals for the improvement of this method follows. After short general reflections on lignin, a new method for the quantitative analysis of lignins is described that provides the conversion of the aromatic component in the lignified membranes into nitrolignin by means of alcoholic nitric acid and its subsequent quantitative analysis.

Investigations on Toughness in Timber—Part III Effects of Different Variables in the Determination of Izod-Values. F. Kollmann, and A. C. Sekhar. *Holz a. R. uW.* V. 16, No. 10, (In German)

Continuing previous investigations on toughness in timber, the variation of Izod-values of a standard-sized specimen with variation in 1) notch angle, 2) direction of blow to the annual rings, and 3) moisture content is studied in the present paper. A parabolic equation and an exponential equation are compared based on curves for variation of Izod values with the moisture content. Certain observations are made near the fiber saturation point, and the need for accurate determination especially in this region is discussed.

Studies on Thickness Variation in Hardboard. Vidya Bhushan Kumar, *Holz a. R. uW.* V. 16, No. 10, (In German)

Variation in thickness in hardboard as influenced by the pressing operation is discussed. Thickness of boards depends on the opening that has pressed the pulp, thus whereas the boards obtained from the uppermost opening are generally thicker at the ends than in the center, those obtained from the lower openings may be thicker at the center. Pulp pressed in the central openings gives fairly uniform products. The thickness variation arising in the upper openings is substantially more than that in the lower or central openings.

Majority of the rejects due to too thick boards results from the upper openings, rejects due to too thin boards are mostly from the lower openings. The probability of rejects due to out-of-tolerance boards falls rapidly after the third opening, but may show a slight rise after opening 19 in a common 20-opening hardboard super water heated press.

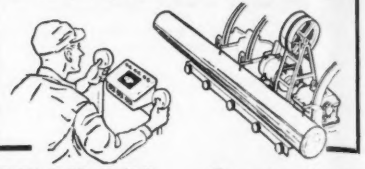
Dry Resawing with conical Circular Saws. L. H. Reineke and G. Hvamb. *Norsk Skodindustri.* V. 12, No. 11. (In Norwegian)

The Norwegian practice of producing boards by the resawing of planks after drying, with conical circular saws, makes dry resawing an important operation. The spring set saws invariably used are compared in sawing accuracy and stability with similar saws fitted with the swaged teeth commonly used in America. No clear-cut superiority was shown by either type of saw because of the masking effects of other sawing factors, but swaged-tooth saws showed greater stability and greater excess of actual kerf width over theoretical kerf width.

INDEX TO ADVERTISERS

	Page
American Cyanamid Co.	2nd Cover
Black Brothers Co.	7-A
Chapman Chemical Co.	3-A
Hitchcock Publishing Co.	6-A
Mattison Machine Works	3rd Cover
Mereen–Johnson Machine Co.	4-A
Mill Equipment, Inc.	32-A
National Casein Co.	5-A
Reichhold Chemicals, Inc.	2-A
Simpson Timber Co.	18-A
Washington Iron Works	4th Cover
Wilco Machine Works	32-A
Williams Patent Crusher & Pulverizer Co.	32-A
Wisconsin Foundry and Machine Co.	18-A
Wood Treating Chemicals Co.	18-A

SELECTRIC® sets the pace in sawyer-operated setworks systems.



FROM 2 TO 30 H.P. Write for complete information on the system engineered for your production requirements.

- Greater Sawing Accuracy
- Improved Grade Recovery
- Increased Production
- Lower Operating Costs
- Reduced Maintenance Costs

MILL EQUIPMENT INC.

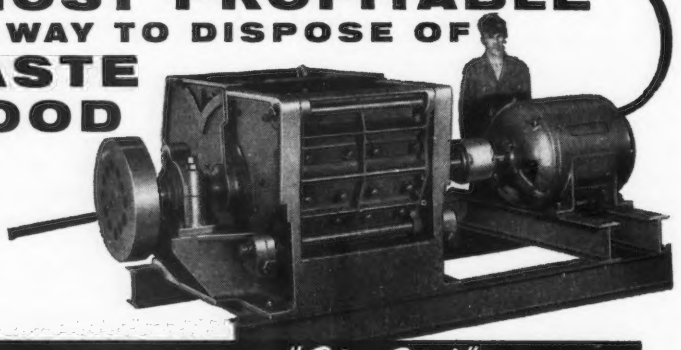
5219 First Ave. South Seattle 8, Wash.

WILCO REFUSE BURNER

Three Models. Complete Range of Sizes. Lowest-cost installation. Prefabricated, one-piece panels. Exclusive triple-draft. Sizing engineers available to you.

WILCO MACHINE WORKS, INC.
Municipal Airport • Memphis, Tenn.
P. O. Box 3722 • WHitehall 8-4555

MOST PROFITABLE WAY TO DISPOSE OF WASTE WOOD



WILLIAMS "No-Nife" HOGS

BIG MARKET FOR GROUND WOOD. Chip board and many other ground wood products offer a tremendous market for waste wood—but manufacturers of these products demand uniformity in quality and size—requirements that Williams hogs are fulfilling in dozens of plants. Whether the wood scrap you sell is in chips, sawdust or flour, a Williams will produce more, faster, with less labor, power and upkeep.

BIG INCREASE IN HEAT VALUE. Wood waste for fuel yields more heat when hogged in a Williams for uniform, complete combustion. Unhogged wood restricts air flow, smothers the fire, burns unevenly, creates excessive smoke. Williams equipment also reduces handling costs as much as 75%! When hogged, one man can handle as much as three men can handle in long, cumbersome pieces.

WILLIAMS AUTOMATIC INSTALLATIONS EARN PHENOMENAL PROFITS when used for hogging and conveying wood waste to boiler or stoker—or for grinding, separating and packaging ground and sized wood.

Write for Illustrated Brochure

WILLIAMS BUILDS A COMPLETE LINE
• Hogging, Grinding and Shredding Machines • Vibrating Screens • Air Separators • Conveying Systems • Cyclone Collectors • Complete "Packaged" Plants

WILLIAMS PATENT CRUSHER & PULVERIZER CO. 2714 N. Ninth St. St. Louis 6, Mo.

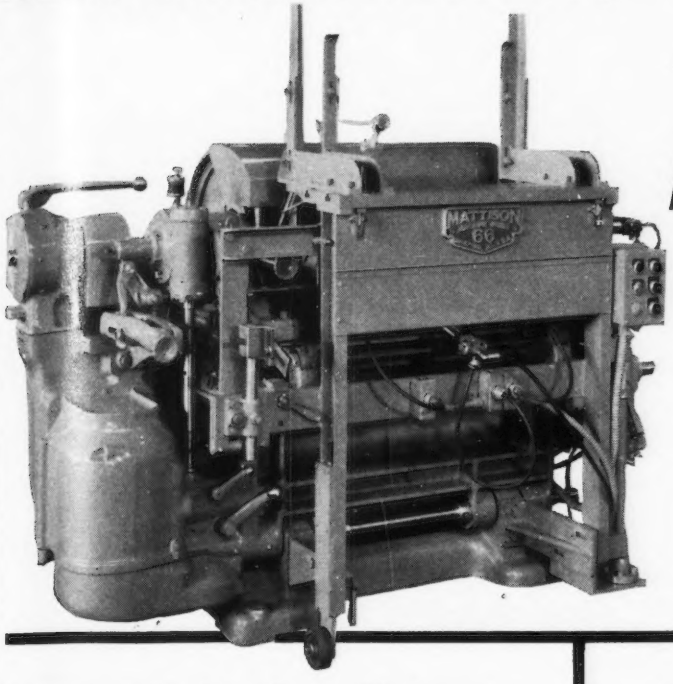
WILLIAMS
CRUSHERS GRINDERS SHREDDERS
OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

ALIVE TODAY!

Arch Lightbody is one of 800,000 Americans cured of cancer because they went to their doctors in time. They learned that many cancers are curable if detected early and treated promptly. That's why an annual health checkup is your best cancer insurance.

American Cancer Society

NEW MATTISON "66" SHAPING LATHE OPERATES AUTOMATICALLY



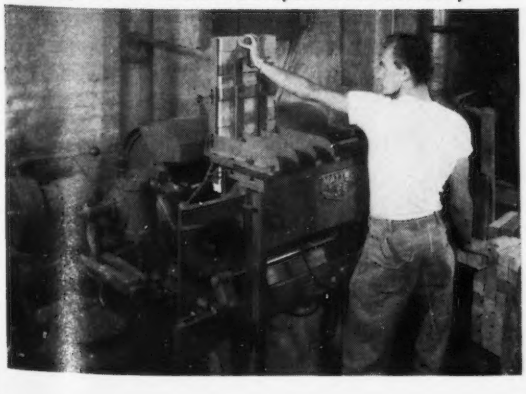
Field tests prove that precision wood-turning operations are done faster . . . with minimum supervision.

Low-cost turning is made possible by automatic cycling of this new Mattison lathe—from centering the piece and engaging knives to ejecting the finished turnings.

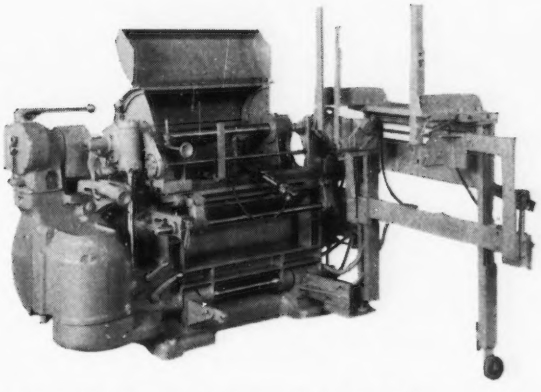
Air power operates the automatic motions of tailstock, carriage, and steadyrest. Easily adjustable to any required production rate. Mattison "66" handles stock from $\frac{3}{4}$" to 4" square and up to 30" long.

EXAMPLES OF SAVINGS: Here are some of the records established by the Mattison "66" at Bergmann Wood Turning, Chicago: Average production of 2400 turnings in 8 hours tripled former results; rough maple stock turned at the rate of 7 pieces per minute instead of 2 pieces—average on manually operated lathes.

Operator just makes the setup and pushes the button; one man can easily keep two automatic lathes in operation simultaneously.



HOPPER-FEED ATTACHMENT is new convenience feature



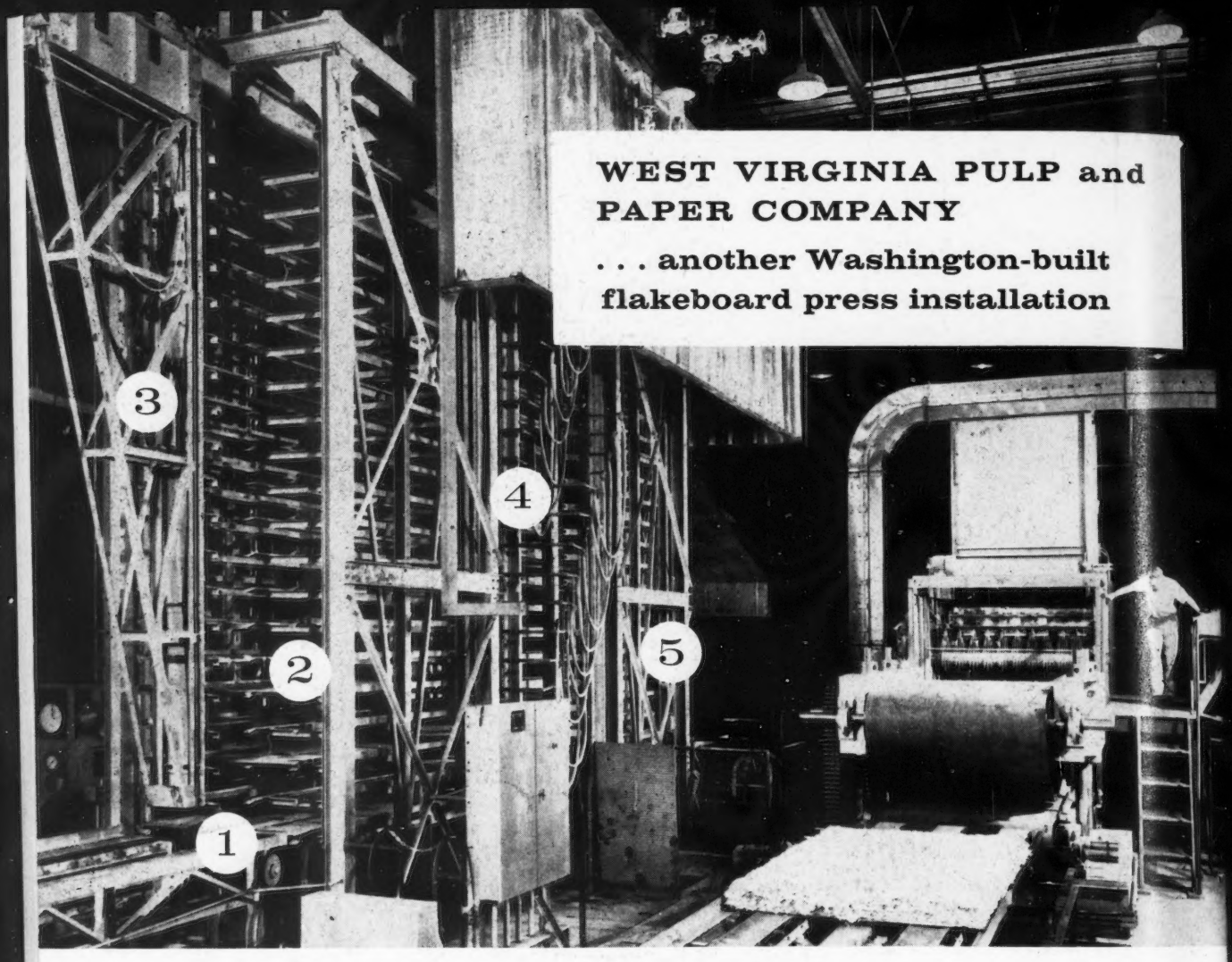
Once the hopper is loaded, feeding is automatic. Can be swung away from lathe, giving easy access to knives for whetting, touching up, or setting. Write for details today.

MATTISON
MACHINE WORKS
ROCKFORD, ILL., U.S.A.

MATTISON

WOODWORKING MACHINERY

"Built better . . . to produce better quality"



WEST VIRGINIA PULP and PAPER COMPANY

. . . another Washington-built flakeboard press installation

In right foreground a flakeboard mat leaves the prepress on its way to final curing in the Washington-built pressing stage at the left. The injector (1) loads the mats into the elevator-type loader cage (2); with a full load of 20 mats the loader ram (3) moves the entire load into the 58" by 102" hydraulic press (4). Each load is compressed for a predetermined length of time under high and low pressures. At the completion of the low pressure cycle the press automatically opens and the unloader (5) removes cured boards from the press and ejects them one at a time onto the conveyor.

• • •

Still available are copies of the 16-page brochure "Washington presses and accessory equipment," featuring in-plant photographs, operating data and equipment diagrams of eight leading board plants. Included are particle board, flakeboard and wet and dry hardboard processes. Write to Washington Iron Works for FREE copy.

LOCATION: Tyrone, Pennsylvania
PLANT ENGINEERS: Miller Hofft Inc.
PRODUCT: Westvaco FLAKEBOARD

A 20-opening Washington hot press and companion loading and unloading equipment form the heart of the new million dollar plant marking the entry of West Virginia Pulp & Paper Co. into flakeboard manufacture.

In this Miller Hofft system, Aspen billets are processed into Westvaco flakeboard in 30 to 40 minutes. Key to this high production is the fully automatic pressing stage. The Washington designed and built mat injector, elevator-type loader, press, elevator-type unloader and board ejector handle the curing process without manual control. Cycle time, heat and pressure are pre-set for completely automatic operation.

This is another example of the adaptability of Washington presses and accessory equipment to individual plant layout, process and product requirements of flakeboard, particle board or hardboard manufacture. For complete information write to Washington Iron Works, 1500 Sixth Avenue South, Seattle 4, Washington.

WASHINGTON presses and accessory equipment

HOT PLATE PRESSES • PULP BALING PRESSES • SPECIAL HYDRAULIC PRESSES • AUTOMATIC PRESS LOADERS AND UNLOADERS • COMPLETE DRY PROCESS HARDBOARD FORMING LINE EQUIPMENT

WASHINGTON IRON WORKS